

CONNECTICUT RIVER FLOOD CONTROL PROJECT

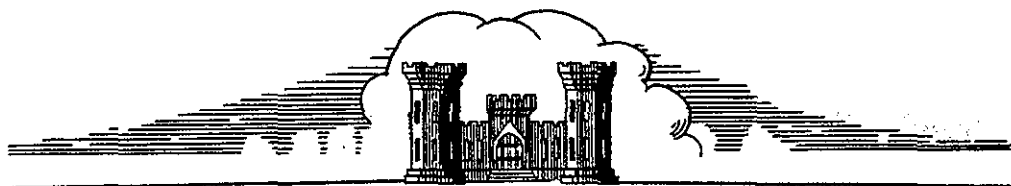
ENGINEERING DIVISION FOR CIVIL ENGINEERING
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HOLYOKE, MASS.

CONNECTICUT RIVER, MASSACHUSETTS

ANALYSIS OF DESIGN
FOR
LOCAL PROTECTION WORKS

FISCAL YEAR 1939 DIKE SECTION, INCLUDING
PUMPING PLANTS, ITEM H1.2 - CONTRACT



APRIL 1939

CORPS OF ENGINEERS, U.S. ARMY

U.S. ENGINEER OFFICE

PROVIDENCE, R.I.

CONNECTICUT RIVER FLOOD CONTROL

ANALYSIS OF DESIGN

HOLYOKE DIKE

FISCAL YEAR 1939 SECTION

MASSACHUSETTS

ITEM H1. 2

CORPS OF ENGINEERS, UNITED STATES ARMY

UNITED STATES ENGINEER OFFICE

PROVIDENCE, RHODE ISLAND

ANALYSIS OF DESIGN

HOLYOKE, MASSACHUSETTS

FISCAL YEAR 1939 SECTION

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HOLYOKE DIKE

PERTINENT DATA

Location - West bank, Connecticut River, Holyoke, Massachusetts.

Area protected 40 acres

Type of property protected Industrial

Elevations (Above Mean Sea Level Datum)

From Station	To Station	Top of wall or dike - Elevation	Average low water - Elevation
-(0+41)	:0+90	: 79.0	: 56.0 to 55.9
0+90	:5+90	: 79.0 to 79.67	: 55.9 to 55.8
5+90	:8+00	: 79.67 to 80.0	: 55.8 to 55.7
8+00	:11+10	: 80.0	: 55.7 to 55.5
11+10	:33+59.22	: 80.0	: 55.5 to 52.5
33+59.22	:34+58.83	: 80.0	: 52.5 to 51.7
34+58.83	:Tailrace No. 6	: 80.0 to 79.83	: 51.7
Tailrace No. 6	:36+62.80	: 79.83 to 79.58	: 51.7 to 51.0
36+62.80	:Stop-log No. 5	: 79.58	: 51.0
Stop-log No. 5	:B+22.26	: 79.58	: 51.0
B+22.26	:B+361.72	: 79.58 to 78.92	: 51.0 to 50.4
B+361.72	:Tailrace No. 7	: 78.92	: 50.4 to 48.3
Tailrace No. 7	:41+27.29	: 78.92	: 48.3
41+27.29	:43+64.29	: 78.92 to 78.42	: 48.3 to 48.1
43+64.29	:Tailrace No. 8	: 78.42	: 48.1
Tailrace No. 8	:44+55.77	: 78.42	: 48.1
44+55.77	:49+68.09	: 78.42 to 77.33	: 48.1 to 47.8
49+68.09	:Tailrace No. 9	: 77.33	: 47.8
Tailrace No. 9	:50+57.09	: 77.33	: 47.8
50+57.09	:52+25.70	: 77.33 to 77.0	: 47.8 to 47.6
52+25.70	:Tailrace No. 10	: 77.0	: 47.6
Tailrace No. 10	:53+59.61	: 77.0	: 47.6
*53+59.61	:55+06.13	: 77.0 to 76.50	: 47.6 to 47.5
55+06.13	:Tailrace No. 11	: 76.50	: 47.5
Tailrace No. 11	:56+69.13	: 76.50	: 47.5
56+69.13	:58+01.45	: 76.50 to 76.25	: 47.5 to 47.3
58+01.45	:Tailrace No. 12	: 76.25	: 47.3
Tailrace No. 12	:59+79.12	: 76.25	: 47.3
*59+79.12	:60+35	: 76.25	: 47.3

*Dike grades between Station 53+59.61 and 59+79.12 are 2'-0" higher than elevations shown.

Dike - Maximum height 12 feet
 Total length (3 sections) 380 feet
 Total impervious fill 2,000 cu.yds.
 Total random fill 2,400 cu.yds.
 Total topsoil 500 cu.yds.

<u>Concrete Walls - Type of wall</u>		Cantilever and buttress
	Maximum height (above ground)	18 feet
Gates and	Maximum height (above top of base)	23 feet
Stop-log	Total length	5,020 feet
Structures	Reinforcing steel	2,320,000 lbs.
	Steel sheet piling (5,500 linear feet)	136,000 sq.ft.
	Concrete - Class "A"	11,400 cu.yd.
	Concrete - Class "B"	10,450 cu.yd.

Pumping Stations -

Sta.:	At :	Inside :	Floor :	Type :	Horse :	Capacity :	No. :	Sta. :	Cranes :
tion:	Tail:	Dimen:	Height:	of :	Power:	Each Pump :	Pumps:	Capa:	
No. :	race:	sion of:	Above :	Pump :	Elec:	at 17' head:	per :	city :	
:	No. :	Build:	Sump :	:	tric :	:	Sta. :	:	
:	:	ing :	:	:	Motor:	G.P.M. :	:	G.P.M.:	
1	: 1	: 19'-9"	: 21'-0"	: Propeller:	100	: 14,000	: 2	: 28,000	: 1
	:	: by :	:	: type :	:	:	:	:	:
	:	: 19'-6"	:	:	:	:	:	:	:
2	: 4	: 17'-10"	: 18'-6"	: Propeller:	100	: 14,000	: 2	: 28,000	: 1
	:	: by :	:	: type :	:	:	:	:	:
	:	: 20'-0"	:	:	:	:	:	:	:
3	: 7	: 17'-10"	: 22'-0"	: Propeller:	125	: 17,500	: 2	: 35,000	: 1
	:	: by :	:	: type :	:	:	:	:	:
	:	: 20'-0"	:	:	:	:	:	:	:
4	: 10	: 17'-10"	: 22'-0"	: Propeller:	125	: 17,500	: 2	: 35,000	: 1
	:	: by :	:	:	:	:	:	:	:
	:	: 20'-0"	:	:	:	:	:	:	:

Gate Structures -

Tailrace:	No. of :	Size of Gate :	Openings:	Length of:	Height over:	Length of
No. :	Gates :	Height :	Width :	Strucutre:	Tailrace :	Wingwalls
1 & 2	: 2	: 11'-0"	: 11'-0"	: 27'-5"	: 28'-0"	: 15'-4"
	:	: 11'-0"	: 11'-0"	:	:	:
4	: 2	: 12'-0"	: 14'-0"	: 34'-5"	: 28'-6"	: None
	:	: 12'-0"	: 14'-0"	:	:	:
6	: 1	: 12'-0"	: 14'-0"	: 19'-0"	: 39'-10"	: None
7	: 3	: 11'-0"	: 13'-0"	: 48'-4"	: 36'-11"	: 40'-1"
	:	: 11'-0"	: 13'-0"	:	:	: 37'-5"
	:	: 11'-0"	: 13'-0"	:	:	:
8	: 2	: 11'-0"	: 13'-0"	: 30'-8"	: 36'-5"	: 30'-0"
	:	: 11'-0"	: 10'-0"	:	:	: 31'-0"
9	: 1	: 12'-0"	: 14'-0"	: 19'-0"	: 36'-4"	: 40'-0"
	:	:	:	:	:	: 30'-0"
10	: 2	: 11'-0"	: 10'-0"	: 26'-5"	: 36'-0"	: 89'-0"
	:	: 11'-0"	: 10'-0"	:	:	: 10'-0"
11	: 1	: 11'-0"	: 13'-0"	: 18'-0"	: 35'-6"	: 72'-6"
	:	:	:	:	:	: 72'-6"
12	: 2	: 11'-0"	: 10'-0"	: 27'-8"	: 37'-3"	: 76'-0"
	:	: 11'-0"	: 10'-0"	:	:	: 75'-0"

I. INTRODUCTION

I. INTRODUCTION

A. AUTHORIZATION. - The Flood protection works from the Holyoke Dam to Mosher Street are a part of the local protection works for the City of Holyoke, Massachusetts. The original project is included in the Comprehensive Plan of Flood Control for the Connecticut River as described in House Document No. 455, 75th Congress, 2d Session, and is authorized under the Flood Control Act approved June 28, 1938.

B. NECESSITY FOR THE PROTECTION. - A considerable area between the Holyoke Dam and Mosher Street was inundated during the great flood of 1936 which caused extensive damage. This area, which forms part of the City of Holyoke, is fully occupied by industrial plants. Among the important properties in this section are the municipal gas and electric plants, Valley Paper Company, the Holyoke Water Power Company, and six divisional plants of the American Writing Paper Company. To effect complete protection during flood stages, the tailraces must be shut off from the river and the elevation of the water in them and behind the protective works held below a level at which damage within the area would begin. While the flood gates on the tailrace conduits are closed the industrial plants cannot utilize their water power.

C. DESCRIPTION OF EXISTING WATER POWER DEVELOPMENT. - Adjacent to the area to be protected and partially within it there exists a water power development system owned and operated by the Holyoke Water Power Company. This company has built a dam across the Connecticut River and diverts water through a system of canals as shown on Plate No. 2 entitled "General Plan." These canals run behind and above the industrial

plants which draw water from the canals and develop their individual power requirements by use of water wheels of various sizes and capacities. Some of the plants use water for their manufacturing processes and draw this water also from the canals. All waters drawn from the canals are discharged finally into the various wasteways and tailraces as indicated on Plate No. 2.

D. CONSULTATIONS WITH CITY, RAILROAD, AND OTHER OFFICIALS. - Before and during the actual design of the protective works, consultations were held with representative officials of the City of Holyoke, the Holyoke Water Power Company, the American Writing Paper Company, the Valley Paper Company, and the New York, New Haven and Hartford Railroad. The alignment of the protective works, the individual plant discharges to take care of, and their related problems affecting the industrial plants were the main subjects of discussion. Track clearances required at the stop-log structures and other points were discussed with the railroad officials and their engineers. Methods of providing for the numerous drains from the Holyoke Gas and Electric plants were discussed with the superintendent of the plants. The final designs for these protective works have been prepared with a view toward a minimum disturbance of the existing plants and railroad and to give due consideration not to hamper any future developments.

E. DESCRIPTION OF THE PROTECTION WORKS.

1. General. - Plates No. 1 and No. 2 show the general location of this project. An initial section known as the "Initial Fiscal Year 1939 Unit" is now under construction by hired labor forces of the District.

This section extends from the No. 1 overflow of the Holyoke Water Power Company First Level Canal, downstream 600 feet with similar type wall construction as described at the upstream end of the "Fiscal Year 1939 Section."

The continuation of construction from the "Initial Fiscal Year 1939 Unit" as covered in this Analysis of Design will be known as the Fiscal Year 1939 Section and extends to Mosher Street.

It was originally proposed to build an earthen dike along the alignment but the space or ground area required entailed huge property damages and construction costs, and the concrete wall was adopted as an economical alternate. The total length of the concrete wall will be approximately 5,020 feet with an average height of 12 feet above ground. A total length of approximately 380 feet of earth dike with an average height of 6 feet will be used. A steel sheet piling cutoff of total length of 5,500 linear feet is provided. There will be four pumping stations, five stop-log structures, nine gate structures and one concrete plug in an abandoned tailrace conduit.

2. Area between the Holyoke Dam and No. 2 Wasteway. - The protective works will form a continuation of the initial unit and will consist of a similar type of concrete wall following the top of the bank around the Holyoke Gas Works to the No. 1 and No. 2 tailraces as indicated on Plate No. 2 entitled "General Plan." In this area the wall will have a concrete apron, placed on the face of the existing masonry wall, and will extend from the base of the vertical stem of the flood wall to a concrete or sheet piling cutoff in ledge rock. Elsewhere the wall will be of the cantilever type with the base four feet below the normal ground

surface, and will have a steel sheet piling cutoff to ledge rock or impervious material. One railroad stop-log structure (Stop Log No. 1) will be provided in this stretch of wall for the New York, New Haven and Hartford Railroad siding servicing the plants within the protected area. At Tailrace No. 1 a gate structure and a pumping station will be built. The gate structure will be used to shut off the tailrace during high-water periods, thus preventing damaging backwater. The pumping station will receive and discharge the seepage and drainage behind the protected area involved. A vehicular stop-log structure (Stop Log No. 2) will be built adjacent to the pumping station to permit access, as now exists, to the Gas Works from North Bridge Street. From Stop Log No. 2 the concrete wall will extend to the bank of the First Level Canal paralleling Conduit No. 3. The portion of the flood wall and above-mentioned structures between the initial unit and the bank of the First Level Canal will comprise a complete unit of flood protection.

3. No. 2 Wasteway. - Conduit No. 3 is an overflow wasteway from the Second Level Canal, emptying into No. 2 Wasteway, and must be kept open to avoid interference with the operations of the industrial plants in the upper areas. This overflow also provides some protection for the protected areas against overtopping of the Second Level Canal and bank if the Holyoke Water Power Company's head gates at the dam failed to close completely.

4. No. 2 Wasteway to South Hadley Falls Bridge (County Bridge). - The area between Conduit No. 3 and North Bridge Street is protected on the landside by the bank of the Second Level Canal and on the riverside it will

be protected by the proposed flood wall and structures mentioned herein-after. The flood wall in this area will begin on the south side of Conduit No. 3, at the bank of the Second Level Canal, and will have an alignment parallel to Conduit No. 3 to a vehicular stop-log structure (Stop Log No. 3) at Wasteway No. 2. Stop Log No. 3 will form a part of the general plan, in conjunction with Stop Log No. 2, to provide access to the Gas Works from North Bridge Street. From Stop Log No. 3 a concrete wall will extend to Tailrace No. 4 where there will be a pumping station and a gate structure. The wall will then continue on across Tailrace No. 5, where there will be a concrete plug in the conduit, to a railroad stop-log structure (Stop Log No. 4) and then to the north side of North Bridge Street near the County Bridge. The steel sheet piling cutoff will continue through the bridge approach to the south side of the South Hadley Falls Bridge.

5. South Hadley Falls Bridge to Mosher Street. - The concrete wall will begin again at the south side of North Bridge Street and will extend across Tailrace No. 6 to the pumping station and gate structure at Tailrace No. 7. One railroad stop-log structure (Stop Log No. 5) will be installed in the wall just south of Tailrace No. 6. The concrete wall will then continue across Tailraces No. 8 and No. 9 to the pumping station and gate structure at Tailrace No. 10. Gate structures are to be built at Tailraces No. 8 and No. 9.

From the gate structure at Tailrace No. 10 a concrete wall will extend to a section of earth dike, which runs to Mosher Street, intercepted by gate structures No. 11 and No. 12 and their wingwalls. Steel sheet

piling will be provided under the full length of these protection works except where the concrete structure is keyed into the rock foundation.

6. Provisions for handling water within the areas protected. -

a. General. - The construction of these protective works will result in preventing natural drainage, seepage from the canal system and sewage from reaching the Connecticut River during high-water periods. A detailed discussion of the quantity of water involved will be found in Section IV D. To prevent the accumulation of this aforementioned water at damaging levels, four pumping stations will be built to discharge the water into the Connecticut River during the flood periods.

b. Drainage systems. - The drainage system in the area upstream from No. 2 Wasteway will be a continuation of the drainage system for the "Initial Fiscal Year 1939 Unit," now under construction. The combined system will drain an area of approximately 7 acres and will consist generally of a V.C. pipe drain laid with open joints in a gravel trench which will follow the landside toe of the flood wall throughout its length. The elevations of the drains, conduits and pipes are established to maintain the water level back of the protective works at least 2 feet below the level of the basements of the various plants. These basements are connected direct to tailraces by drains, hence no hydraulic grade need be considered. In the combined system, there will be 25 inlets with grating covers which facilitate turning surface runoff into the drainage system; 8 of these inlets are in the "Initial Fiscal Year 1939 Unit." Along the riverside of the area the drain will slope from the Holyoke Water Power Company spillway (at the upstream limit of the "Initial Fiscal Year 1939

Unit") and from a divide point on the north bank of No. 2 Wasteway opposite Tailrace No. 4 to an inlet located about midway between these two points, where the combined discharge is diverted into an 18-inch pipe which will drain into Tailrace No. 1. Each of the two drains along the river will have a by-pass about midway in its length which will permit drainage water to discharge directly through the flood wall into the river, gate valves being provided to close these outlets during high-water periods. Along the north bank of No. 2 Wasteway, the drain will slope from the divide point opposite Tailrace No. 4 to Tailrace No. 1 and will discharge back of the flood gates. Along the west side of Tailrace No. 3 the drain will slope from the end of the flood wall at the First Level Canal to Tailrace No. 2, which will discharge back of the flood gates at Tailrace No. 1. Thus, the water table in this entire area may be held constant by the pump installation at Pumping Station No. 1. There will be two short lengths of rock drain trench in this area, near the First Level Canal and near the junction of No. 2 Wasteway and the Connecticut River. These rock drains will discharge into inlets connected to the drainage system. Existing drains and pipes which at present discharge into the river or No. 2 Wasteway will be cared for either by connecting them to the drainage system, or by carrying them through the flood wall and providing a gate valve to close them during high-water periods. The latter method has been adopted wherever the discharge is of such nature that it might be objectionable in the drainage system or pumping installation.

The area, from No. 2 Wasteway to the South Hadley Bridge, has a total drainage area of about 7 acres. To care for the surface drainage

within the protected area, inlets (10) will be provided at points of concentrated flows adjacent to the flood wall. The pipes connecting these inlets will be laid with open joints in a gravel bed and sloped to Pumping Station No. 2 at Tailrace No. 4. The drains in all cases will be as low as or lower than the base of the landside toe of the flood wall and will provide a means of accelerating the runoff of seepage behind the wall as well as lowering the ground-water table. For a short distance, the drainage trench and pipes will be under the landside toe slab due to limited space between the wall and the existing buildings. Where the gravel roadway lies on top of the landside toe slab and the drainage trench is under the slab, weep holes and lateral rock drains will be provided. Under the railroad tracks, and in other places subject to possible extreme loads, cast-iron pipe, with open joints, will be used, all other piping will be of vitrified clay. The landside toe slab of Stop Log No. 4 will be covered with a bedding of gravel and the slab sloped to drain the "pocket" formed by the construction of the structure. Where the relocated railroad tracks will be close to the wall, it will be necessary to leave the wall with the main drainage system, and use lateral rock drains to drain the area affected.

From the South Hadley Falls Bridge to Mosher Street the area presents a simpler problem of drainage. A simple system of open joint pipes or rock drains will be used draining to two pumping stations. No difficult problems were encountered in this area and the standard drainage practices were applied. Sewage lines as intercepted will be diverted into the new system.

c. Tailrace gates. - The elevations and sizes of the

(Classes 2, 3, 4, and 5), (3) moderately impervious formation (Classes 6 and 7), and (4) impervious formation (Classes 8, 9, 10, and 11). Seepage through the artificial overburden (fill), which contacts the river for the entire length of the proposed dike, will be greatly reduced by steel sheet piling. This piling is driven to rock where practicable or to such depth as to prevent piping or excessive seepage. Any seepage that does occur will be effectively handled by a drainage system located in back of the wall.

B. BORROW AREAS. - Two borrow areas for embankment materials are proposed as shown on Plate No. 9 titled "Borrow Areas." The source of impervious materials is Area "B" where deposits of mixed materials graded from gravel or coarse sand to medium or fine silt occur. The natural moisture content of this material is only slightly above that necessary for maximum compaction and no trouble should be experienced in placing it. Pervious materials are available in Area "C" where coarse to medium sand deposits occur.

C. EMBANKMENT MATERIALS. - Mechanical analysis curves of typical samples of materials encountered in the contemplated borrow areas are shown on Plate No. 12.

Compaction characteristics of the proposed selected impervious and random impervious borrow materials are expressed on Plate No. 13 in terms of dry compacted weight in pounds per cubic foot, and water content, per cent. These characteristics are typical of results obtained from Proctor analyses performed upon samples of soil from the proposed borrow area for impervious material. The curve indicates that a maximum dry

II. SELECTION OF ALIGNMENT AND TYPE OF PROTECTION

II. SELECTION OF ALIGNMENT AND TYPE OF PROTECTION

A. SELECTED ALIGNMENT. - The selected alignment as described in Section I E is considered to be the most economical and practicable of any of the possible alignments, as more fully explained in Paragraph B. It affords protection from floods and high water to all plants in the area from the dam of the Holyoke Water Power Company to Mosher Street and also to all railroad sidings in this area with the exception of about 1,000 feet of side track between the upstream side of No. 2 Wasteway and a point about 350 feet downstream from the County Bridge. The flood wall continues from the Initial Fiscal Year 1939 Unit, which is under construction by hired labor, and which begins at the abutment of the No. 1 Wasteway, and ties into the First Level Canal bank on the north side of Wasteway No. 2 skirting the industrial property on the riverside. Beginning again at bank of the Second Level Canal, the flood wall continues through the fill for the approach to the South Hadley Falls Bridge to high ground on the riverside of the railroad tracks just upstream from Mosher Street.

B. OTHER ALIGNMENTS CONSIDERED. - Three alternate alignments were considered which would afford protection to portions of, or all of the 1,000 feet of railroad track mentioned above.

1. The first which would cross No. 2 Wasteway and continue downstream on the outside of all railroad tracks, thus giving the railroad complete protection was rejected because it required blocking the No. 2 Wasteway which must be kept open during high water to prevent flooding of the area from the Second Level Canal. Pumping was considered in

connection with this plan, but the excessive cost and maintenance of such a pumping station could not be justified by the additional protection to be gained.

2. The second alternate consisted of carrying the flood wall around No. 2 Wasteway as in the selected alignment, and outside of all railroad tracks except at the trestle across No. 2 Wasteway. This alternate involved a wall resting on lower ground, and a crossing underneath the County Bridge, the lower truss members of which extend nearly 3 feet below the grade of the flood wall, and it was rejected because the additional cost of the higher flood wall and alterations to the County Bridge was not justified by the possible cost of any damages caused to the railroad by the flooding of this 900-foot length of track.

3. The third alternate consisted of installing an additional stop-log structure about 200 feet downstream from Tailrace No. 4 which would eliminate the necessity of relocating the railroad siding in this area. This alignment was rejected because of the increased costs due to railroad relocation and also because another opening in the wall would be necessary, adding greater maintenance costs and complications.

4. Alternate alignments for portions of the flood wall downstream from the County Bridge, which involved moving the wall closer to the railroad tracks to take advantage of the slightly higher ground, were discarded because they introduced more difficult construction and more interference with the railroad, and did not justify the small saving in cost of the slightly lower wall.

5. None of the alternate alignments mentioned above affords

additional protection to the City of Holyoke or to any of the mills adjacent to the Connecticut River, the sole beneficiary in all three cases being the New York, New Haven and Hartford Railroad. It is believed that the annual cost of this damage would be far less than the annual cost of protection against such damage.

C. TYPE OF PROTECTION. - A concrete flood wall was selected for the entire project with the exception of about 380 feet at the downstream end. Upstream from the County Bridge an earth dike was impracticable on account of the limited clearances. Downstream from the County Bridge an earth dike was considered, but the height and consequent base width made the dike impracticable except at the lower end of the project, where the flood stage is only a few feet above the natural ground surface.

III. SOIL INVESTIGATIONS.

III. SOIL INVESTIGATIONS

A. SITE AND FOUNDATION CONDITIONS. - The upper portion of the overburden throughout the entire length of the proposed dike location consists of fill. Subsurface explorations indicate that the natural ground surface of the original river bank is deeply buried, the filled ground extending back from the present river bank for some distance. Foundation investigations were made by means of wash borings, dry samples being obtained frequently by means of standard sampling equipment. The location and record of these explorations are shown on Plates Nos. 3, 4, 5, and 6, titled "Subsurface Explorations No. 1, No. 2, No. 3, and No. 4," respectively. Table I gives the soils classification as adopted by the Providence District.

The fill noted above ranges in thickness along the proposed dike location from about 7 feet to about 27 feet. This is indicated on Plate No. 7 titled "Geologic Section." The fill consists of earth materials together with varying amounts of cinders, brick, and debris. Explorations indicate that in general the fill lies on two different types of natural deposits. One of these is a pervious formation composed chiefly of Class 5 with some Classes 3 and 4. The other deposit is a moderately impervious formation composed of Classes 6 and 7. These two formations predominate with minor lenticular beds of impervious Classes 8, 9, 10, and 11. Numerous boulders and decomposed shale fragments were encountered in the overburden throughout the entire length of the proposed dike.

Rock outcrops occur in the river bed at the upper end of the dike from Station 0+00 to about Station 8+50. (See Plate No. 3.) Downstream from this point, explorations indicate ledge at varying depths ranging

from elevation 50 to below elevation -10. The rock is a thinly bedded shale becoming somewhat sandy in places and varying from red to grey in color. The upper portion of the shale for a depth of from 1 to 5 feet is weathered and fractured.

The various soil classes recognized in the Providence Soil Classification, some of which are noted above, are described in Table No. II and shown graphically in Plate No. 8 titled "Diagram Showing Limits of Soil Classes."

TABLE NO. I

General Type:	Class	Coefficient of Permeability*	
		cm./sec.	ft./min.
Uniform	2	120 - 400	240 - 800
	4	20 - 120	40 - 240
	6	5 - 20	10 - 40
	8	1 - 5	2 - 10
	10 or 10C	0.1 - 1.0	0.2 - 2.0
	12 or 12C	Less than 0.1	Less than 0.2
Variable	1	Greater than 1000	Greater than 2000
	3	200 - 1000	400 - 2000
	5	50 - 200	100 - 400
	7	15 - 50	30 - 100
	9	3 - 15	6 - 30
	11	0.2 - 3.0	0.4 - 6.0
	13 or 13C	Less than 0.2	Less than 0.4

*The values in the above table must be multiplied by 10^{-4} .

Table No. I indicates the range limits of permeability for each class of overburden material. These values have been determined from laboratory tests of both undisturbed and disturbed samples. The principal use of this table is as a guide for evaluating relative permeabilities.

As indicated on Plate No. 7, "Geologic Section," the dike foundation is divided into four distinct zones of varying permeability. These are shown as (1) artificial overburden (fill), (2) pervious formation

(Classes 2, 3, 4, and 5), (3) moderately impervious formation (Classes 6 and 7), and (4) impervious formation (Classes 8, 9, 10, and 11). Seepage through the artificial overburden (fill), which contacts the river for the entire length of the proposed dike, will be greatly reduced by steel sheet piling. This piling is driven to rock where practicable or to such depth as to prevent piping or excessive seepage. Any seepage that does occur will be effectively handled by a drainage system located in back of the wall.

B. BORROW AREAS. - Two borrow areas for embankment materials are proposed as shown on Plate No. 9 titled "Borrow Areas." The source of impervious materials is Area "B" where deposits of mixed materials graded from gravel or coarse sand to medium or fine silt occur. The natural moisture content of this material is only slightly above that necessary for maximum compaction and no trouble should be experienced in placing it. Pervious materials are available in Area "C" where coarse to medium sand deposits occur.

C. EMBANKMENT MATERIALS. - Mechanical analysis curves of typical samples of materials encountered in the contemplated borrow areas are shown on Plate No. 12.

Compaction characteristics of the proposed selected impervious and random impervious borrow materials are expressed on Plate No. 13 in terms of dry compacted weight in pounds per cubic foot, and water content, per cent. These characteristics are typical of results obtained from Proctor analyses performed upon samples of soil from the proposed borrow area for impervious material. The curve indicates that a maximum dry

compacted weight of 130 pounds per cubic foot can be obtained at an optimum water content of 9.2 per cent.

Tests for maximum and minimum density were performed upon samples of the soil from the proposed borrow area for free-draining material. Averages of the values obtained are as follows:

Maximum density = 104.7 lbs./cu. ft.
Minimum density = 88.5 lbs./cu. ft.

Assuming the "degree of compaction" for maximum stability to be 80 per cent, it is indicated that the most desirable density to be obtained in the embankment is 101.0 lbs./cu.ft. This was determined from the equation

$$P_v = \frac{e_0 - e}{e_0 - e_{100}} \times 100$$

in which P_v = degree of compaction, per cent

e = void ratio of material in embankment

e_0 = void ratio of material at minimum density

e_{100} = void ratio of material at maximum density

Values of the angle of internal friction, ϕ , as obtained by direct shear tests, are within the range $33^\circ - 37^\circ$ for all types of borrow materials encountered in the contemplated areas.

TABLE II.

SOIL CLASSIFICATION
U.S. ENGINEER OFFICE
PROVIDENCE, R. I.

CLASS :	DESCRIPTION OF MATERIAL
1 :	<u>Clean Gravel.</u> - Contains little coarse to medium sand.
2 :	<u>Uniform Coarse to Medium Sand.</u> - Contains little gravel and fine sand.
3 :	<u>Variable - Graded from Gravel to Medium Sand.</u> - Contains little fine sand.
4 :	<u>Uniform Medium to Fine Sand.</u> - Contains little coarse sand and coarse silt.
5 :	<u>Variable - Graded from Gravel to Fine Sand.</u> - Contains little coarse silt.
6 :	<u>Uniform Fine Sand to Coarse Silt.</u> - Contains little medium sand and medium silt.
7 :	<u>Variable - Graded from Gravel to Coarse Silt.</u> - Contains little medium silt.
8 :	<u>Uniform Coarse to Medium Silt.</u> - Contains little fine sand and fine silt.
9 :	<u>Variable - Graded from Gravel to Medium Silt.</u> - Contains little fine silt.
10 :	<u>Uniform Medium to Fine Silt.</u> - Contains little coarse silt and coarse clay. Possesses behavior characteristics of silt.
10 C :	<u>Uniform Medium Silt to Coarse Clay.</u> - Contains little coarse silt and medium clay. Possesses behavior characteristics of clay.
11 :	<u>Variable - Graded from Gravel or Coarse Sand to Fine Silt.</u> - Contains little coarse clay.
12 :	<u>Uniform Fine Silt to Medium Clay.</u> - Contains little medium silt and fine clay (colloids). Possesses behavior characteristics of silt.
12 C :	<u>Uniform Clay.</u> - Contains little silt. Possesses behavior characteristics of clay.
13 :	<u>Variable - Graded from Coarse Sand to Clay.</u> - Contains little fine clay (colloids). Possesses behavior characteristics of silt.
13 C :	<u>Variable Clay.</u> - Graded from sand to fine clay (colloids). Possesses behavior characteristics of clay.

IV. FLOOD HYDRAULICS

IV. FLOOD HYDRAULICS

A. DESIGN FLOOD. - The design flood on which the dike grade is based is the maximum predicted flood reduced by the 20 reservoirs comprised in the Comprehensive Plan of Flood Control for the Connecticut River Basin. The determination of the maximum predicted flood is discussed in Appendix 1 of "The Report of Survey and Comprehensive Plan for the Connecticut River," dated March 20, 1937, and published as House Document No. 455. It has a peak discharge at Holyoke of 304,000 c.f.s., approximately 20 per cent greater than the maximum flood of record.

B. FREEBOARD. - The survey report proposed a uniform freeboard of 3 feet for both concrete walls and earth embankment. This was based on consideration of wave fetch and velocity. The Board of Engineers for Rivers and Harbors recommended that, since the entire reservoir plan might not be effective for some time, the earth section be raised 2 feet, thus giving a freeboard of 5 feet for all earth dikes. The design has been modified to meet this recommendation. Concrete walls were designed to withstand a flood grade higher than the proposed top of wall, in accordance with instructions from the Office of the Chief of Engineers. A further proviso that the walls should be at least up to the grade of the 1936 flood was found to govern the grade of the wall for a very short section near the South Hadley Falls Bridge.

C. CONSTRUCTION AND DESIGN GRADES. - The proposed construction and design grades for concrete walls (mean sea level datum) shown below have been used as the controlling grades.

	Type of Dike	Approx. Report Station	Grade Recom- mended for Con- struction	Design Grade for Con- crete
Upstream end of wall (Initial Fiscal Year 1939 Unit)	Concrete	0	79.0	81.7
Railroad gap	"	9+0	80.0	81.5
Upstream side So. Hadley Falls Bridge	"	31+68	80.0	81.4
Downstream side So. Hadley Falls Bridge	"	32+13	80.0	81.4
	"	51+60	77.0	79.5
	Earth	51+60	78.7	
	"	56+95	78.4	
	Concrete	56+95	76.4	79.3
	"	57+60	76.4	79.3
	Earth	57+60	78.4	
High ground	"	58+95	78.2	

D. PUMPING REQUIREMENTS. - Storm runoff from the area between the Second Level Canal and the dike; headgate leakage into the power plants from the canal; flood gate leakage into the tailrace conduits from the river; seepage from the canal and seepage from the flood wall must be pumped during flood periods. The following assumptions and estimates were made to determine this quantity of water to be pumped:

First: During flood periods all head and tailrace gates, stop logs and pipelines in the walls must be closed.

Second: The area receiving rainfall is approximately 40 acres, the runoff was estimated to have a maximum value of 40 c.f.s., corresponding to a rate of one inch per hour.

Third: The headgate leakage was estimated by making certain rational assumptions as follows:

Assume $1/8$ -inch crack around the entire periphery of each gate and one gate opened 1 inch from bottom at each pump location.

Average head on upper portion of gates = 12 feet.

Head on bottom of gates = 16 feet.

Assuming $c = 0.3$ for crack around gate, velocity of flow therefore equals 8.4 feet per second.

Discharge per foot of crack equals 0.088 c.f.s.

Assuming $c = 0.6$ for opening at bottom of gates.

Velocity of flow equals 19.2 feet per second.

Discharge per foot of crack equals 1.6 c.f.s.

Fourth: The flood gate leakage was estimated by the following assumptions: it was estimated that $1/2$ c.f.s. was the leakage for each gate at Tailrace Structure No. 4. The leakage at the other gates in the section was then proportioned with regard to size of gate and head of water.

Fifth: Seepage from the canal walls was estimated by making the following assumptions:

Path of percolation = 100 feet.

Head of water = 10 feet average.

Transmission constant of the material = 0.31.

Porosity of the material (grain size #5 average 0.6 mm.) = 0.40.

Velocity equals 0.078 feet per minute.

Seepage per 100 feet of wall draining to Tailgate No. 1 equals 1.04 c.f.s.

Owing to the data presented by the Holyoke Water Power Company as to the small loss by seepage in the other areas concerned, the reduced head of the Second Level Canal, the age of the existing canal banks and their observed behavior, the seepage has been reduced to 0.75 c.f.s. per 100 feet of wall.

Sixth: Seepage from the proposed flood wall was estimated after the following assumptions were made:

Area upstream Gate No. 1 and No. 2 (walls keyed into rock) = 0.05 c.f.s. per 100 feet.

Area between Gate No. 1 and No. 2 and South Hadley Falls Bridge (piles to rock) = 0.1 c.f.s. per 100 feet.

Area from South Hadley Falls Bridge to Mosher Street (piles in pervious material) = 0.2 c.f.s. per 100 feet.

Following is a tabulation of the results of the above assumptions:

	Precep:	Gate Leakage:	Seepage	Total Water	Design:	Design Re-
Tail	100%	:	:	:	Require-	quiroments
Gate	Runoff:	Head	Tail	Canal: Wall	ments	for Pump Sta.
	c.f.s.:	c.f.s.:	c.f.s.:	c.f.s.:	c.f.s.:	g.p.m.:
No. 1 :	8.0 :	20.2 :	0.9 :	11.4 :	0.9 :	41.4 : 18,580: 27,870: (1) 27,900
No. 4 :	7.1 :	19.0 :	1.0 :	6.0 :	1.2 :	34.3 : 15,400: 23,100: (2) 23,100
No. 6 :	4.0 :	5.6 :	0.6 :	3.0 :	0.9 :	14.1 : 6,330: 6,330:
No. 7 :	3.6 :	23.4 :	1.5 :	2.0 :	1.0 :	31.5 : 14,140: 21,210: (3) 34,400
No. 8 :	3.5 :	7.0 :	1.4 :	2.6 :	0.8 :	15.3 : 6,870: 6,870:
No. 9 :	3.8 :	3.5 :	0.6 :	2.1 :	0.9 :	10.9 : 4,900: 4,900:
No. 10:	2.8 :	19.2 :	1.0 :	2.0 :	0.6 :	25.6 : 11,490: 17,240:
No. 11:	3.1 :	3.2 :	0.5 :	2.6 :	0.6 :	10.0 : 4,490: 4,490: (4) 32,600
No. 12:	4.1 :	4.6 :	1.0 :	3.0 :	0.6 :	13.3 : 5,970: 5,970:
Totals:	40.0 :	105.7 :	8.5 :	34.7 :	7.5 :	196.4 : 88,170:

Note: Numbers in parentheses are Pumping Station numbers.

Seventh: A comparison of two alternate methods of pumping, viz., by individual pumps at each plant, or by a system of four pumping stations, each serving a group of plants, showed that the latter system would be more economical and satisfactory and it was therefore adopted.

As shown by the foregoing tabulation, the pumping station requirements are based on a 50 per cent increase of estimated discharge values for Pumping Stations No. 1 and No. 2 and 50 per cent increase of estimated values for Gates No. 7 and No. 10 for Pumping Stations No. 3 and No. 4 respectively. The increases in pumping station capacities over the minimum amounts estimated are necessary to provide greater dependability and flexibility of operation. As each station will have two pumps, one will be able to take care of all normal discharges when the other is not able to operate. (See Section VI B 6 for sizes of pumps and number finally adopted.)

V. EARTH EMBANKMENT AND DESIGN CRITERIA

V. EARTH EMBANKMENT AND DESIGN CRITERIA

A. GENERAL DESIGN. - After a careful study to adapt the standard dike section of the Providence District to the conditions at the site, it was determined, in view of economy and good engineering practice, to modify the standard section for this particular stretch of dike. The revised design has an impervious core around and above the sheet pile cutoff. The slopes are of random pervious materials with a landside toe drain to carry any seepage to the drainage system and pumping stations. The slopes are such that the section is considered stable for a rapid drop of the river and affords considerable resistance against seepage. The danger of erosion is considered slight and no riprap will be provided on the dikes. A sheet pile cutoff is necessary throughout the length of the project, since the water table must be held to about Elevation 63 back of the dike.

B. DESIGN CRITERIA. - The dike is designed and constructed to satisfy the following criteria:

1. The crest of the dike is at such a grade that there is no danger of overtopping (Section IV A).
2. The freeboard is sufficient to reduce greatly the danger of overtopping by waves (Section IV B).
3. The slopes of the dike are such that with the materials used in construction they will be stable under all conditions (Section V A).
4. The line of saturation is well within the landside toe (Adequate impervious core provided).

5. Water which passes through and under the dike will, when it comes to drains, have a velocity so small that it is incapable of moving any of the material of which the dike and foundation is composed (for foundation, see Section I and Section III A).

6. There is no possibility for the free passage of water from the riverside to the landside face of the dike (sufficient impervious core and sheet piling).

7. No materials soluble in water are used in any part of the dike (Sections III B and C).

8. The foundation is sufficiently stable to resist undue stresses caused by the embankment load (Section III A).

9. Seepage through the dike and foundation will be reduced to a total quantity well within economic pumping limitations (Section IV D).

VI. MECHANICAL DESIGN

VI. MECHANICAL DESIGN

A. FLOOD GATES. - Under the existing conditions, the flood waters from the Connecticut River produce reverse flow in the tailrace conduits discharging from the various plants. To prevent this reverse flow and subsequent inundation of the buildings due to flood heights in the river, gates will be provided in the outlet structure of all tailrace conduits. The gates will be of the plain vertical slide type controlled by manually-operated hoists located on top of the outlet structures.

It is assumed that the tailrace flood gates will be closed under balanced or nearly balanced head conditions for when the river reaches a critical stage and it becomes necessary to close the tailgates, the plants' head and turbine gates will be closed first. The stoppage of flow will result in the water surface becoming practically level in the tailrace conduits at an elevation equal to the river stage. It is also assumed that the gates will be raised under approximate balanced head conditions, as the protection afforded the inclosed area would be lost if they were raised while any considerable head of water was imposed on them by the river. Should a head of water be built up against the gates from the tailrace side, the gates would be pushed from the guide seals and the gate leakage would equalize the water surfaces on either side in a short period of time.

The gates are designed for maximum head conditions assuming that the river is at flood stage and the tailrace tunnel dry. Where several gates of the same size are used in different outlets, the design is predicated on the maximum load conditions at any one of the similar outlets.

The gates will be rectangular in shape and made up of a series of horizontal wide flange steel beams to which skin and side plates are attached. No member will be stressed greater than 16,000 pounds per square inch under full load conditions. Seals will consist of bronze removable strips. The gates will be operated in structural steel guides securely embedded in concrete.

Each gate will be connected to two pedestal type hand-operated hoists by means of threaded stems. The hoists will be connected to each other to insure uniform raising and lowering of the gates and to prevent binding.

B. PUMPING STATIONS.

1. General. - Prior to the selection of the pumping equipment, a detailed study was made to determine what prime motors should be employed to drive the pumps. Gasoline engines and electric motors were considered with reliability, maintenance, ease of operation and first cost being the principal points in question. The conclusion reached was that the use of electric motors is definitely more desirable than gasoline engines at this site because four independent sources of power are available. They are also relatively simple to operate and require little maintenance. The total cost of electric motor drive is more than that of gasoline engine drive, owing to the fact that it is necessary to provide substations in order to obtain power at a suitable operating voltage. In determining the type of drive to be employed, some consideration was also given to the fact that when the flood protective works are about to be employed there will be numerous gates, valves and stop-log structures to close. This will

require a large force of men and should the pumps be gasoline engine driven, a larger force would be required to start and operate them than if they were electric motor driven.

2. Electric power supply. - There are four independent sources of power available. The first is the municipal system which generates power by steam and distributes it at 4,600 volts principally for lighting purposes. The second is the Holyoke Water Power Company Hydro Station and the third is the Holyoke Water Power Company's combined steam and hydro station. In addition, the Holyoke Water Power Company stations and the municipal system are tied in with the primary distribution system of the Turners Falls Power Company. The Holyoke Water Power Company distributes power at 6,900 and 13,800 volts principally for industrial use (see Plate No. 24 for location of power stations). The three Holyoke power stations are interconnected so that any one of them can furnish power to the other. An examination of the operation of the power systems during the floods of 1927, 1936, and 1938 and the protective measures since provided them, indicate that they can be considered dependable.

3. Electrical distribution system. - The distribution system for supplying electric energy to the pump motors will be made up of two 750 kv.a. outdoor substations and the distribution lines to each pumping station. The first substation will be located adjacent to Pumping Station No. 1. Because of its access to the distribution lines of both power systems, the transformers will be provided with double primaries for the two voltages (13,800 and 4,600 volts). This will enable them to be energized from either source of power. No regulating taps will be provided

because of the close regulation maintained by the power systems. The 2,300 volt feeders (2) from the secondary will pass underground and up to the main feeder disconnecting switch on the station switchboard. The second substation will be located adjacent to Pumping Station No. 4. It will be tied in to the 13,800 volts primary distribution line of the Holyoke Water Power Company. The 2,300 volt feeders from the secondary will be handled in a similar manner to those in the first substation.

Inter-station connecting lines will be sectionalized to isolate faults and to prevent an outage of the entire distribution system as would be the case if they were integral for the whole length of the system. Isolation of faults will be accomplished by means of time directional over-current relays arranged with their time settings cascaded so as to reduce to a minimum the number of pumping stations shut down. All pumping stations will be interconnected by two three-conductor rubber insulated leaded cables run in fibre conduits which will be embedded in the concrete flood wall.

4. Pumping station electrical equipment. - The control for motors and feeders at each pumping station will be centralized at the station switchboard. At Pumping Stations Nos. 1 and 4, substation feeders will be controlled by manually-operated circuit breakers of the oil-filled type having a rated interrupting capacity of 25,000 kv.a. The breakers will be equipped with time overcurrent relays and locking relays to prevent the closing of either breaker while the station bus is already energized. Circuit breakers for sectionalizing the lines between stations will be manually operated and will be provided with time directional over-

current relays. Breakers for motor control will be manually operated and will be provided with thermal overload and time delay undervoltage protection. The thermal overload device will provide running overcurrent protection to the motor. All tripping of main and inter-station feeders will be by means of alternating current from current transformers through tripping reactors. (See Plate No. 28 for circuit diagram.)

5. Electrical operation. - In order to illustrate the functions intended, assume that the system is being fed by the main feeder located at Pumping Station No. 1 and a fault occurs on the line between Pumping Stations Nos. 3 and 4. The circuit breaker on the inter-station feeder between No. 3 and No. 4 will open and the fault will be cleared. All pumping stations, with the exception of No. 4, will continue to operate. The faulted line cleared by the circuit breaker would then be substituted for by the other line paralleling it. Pumping Station No. 4 would be relieved of its load by the time-delay under-voltage relays on each motor and would be energized again by reconnecting the inter-station feeder breakers. Then the motor load would be thrown on and the pumps would resume operation.

6. Pumps. - The principal requirements affecting the selection of the type of pump to be installed were as follows:

- a. They should meet the conditions as to head and capacity.
- b. They should pass such debris as might accumulate in the sumps.
- c. They should have such characteristics that when the elevation of the sump water and the flood waters are at their maximum, the

pumps will deliver their maximum discharge, and that when the elevation of the sump water is at its minimum and the flood waters at their maximum the pump should not reach the "shut-off" point. This is desirable to reduce stop and start operation to a minimum.

The above conditions can successfully be met by the axial flow type of pump. It will meet the head and capacity requirements, pass small drift, and the propeller can be readily designed to meet the characteristics desired. Considering the criteria employed in arriving at the pumping station capacities, two pumps were provided for at each station. Only one pump might be installed to deliver the required capacity, but it would not provide any flexibility in operation and, consequently, would result in considerable stop and start operation except at peak flood conditions. Furthermore, the installation of two pumps provides a margin of safety in that if one pump should fail the other would prevent flooding except under the most severe conditions.

A study of the characteristics curves for various sizes of pumps indicates that two 24-inch pumps can be employed to best advantage in Pumping Stations Nos. 1 and 2, and two 30-inch pumps in Pumping Stations Nos. 3 and 4. The 24-inch pumps will have a rated capacity of 14,000 g.p.m. at 17-foot total head. The 30-inch pumps will have a rated capacity of 17,500 g.p.m. at 17-foot total head. (See Plates 29 to 32, inclusive, for pumping station capacities.)

7. Lighting system. - The lighting system for each pumping station is made up of a 5 kv.a. transformer which delivers current through a lighting panel to the overhead lights, convenience outlet and floodlights.

The floodlights will be used to illuminate the various gate structures in the event that it becomes necessary to operate the gates during the night.

8. Estimated cost. - The preliminary studies made to determine what method of drive should be employed, involved the making of detailed estimates and floor layouts for both gasoline engine and electric motor drive. It was determined from the floor layouts that any structure which would house one scheme would house the other. This is accounted for by the fact that the additional area required for the switchboard for electric driven pumps offsets the smaller space required for the motore and the total space is sufficient for the gasoline engines. Therefore, it may be regarded that the size of the pumping station has been dictated by the pump spacing requirements rather than by the method of drive. In view of this fact, the question of structure cost has been disregarded in the comparison of the estimates.

The proposed gasoline engine drive provided for the use of heavy duty industrial type engines would be capable of continuously driving the pumps through a right angle gear unit at their rated speed under any head condition developed. They would be mounted on concrete bases and be direct connected through flexible couplings to right angle gear units. The gear units would be of the self-contained type designed for transmitting the power from the horizontal engine shaft through a set of special bevel gears to the vertical pump shaft.

It is estimated that the cost of all mechanical and electrical equipment necessary for electric motor drive is \$107,000. Of this amount, it is estimated that \$15,200 will be required for the substations and \$10,700

for the distribution system. The estimated cost of all equipment necessary for gasoline engine drive is \$84,000. Therefore, the electric motor drive is estimated to cost \$23,000 more than the gasoline engine drive. However, it is believed that the added expenditure is justified by the reliability, ease of operation and low maintenance costs obtained by the use of electric motors.

VII. STRUCTURAL DESIGN.

VII. STRUCTURAL DESIGN.

A. GENERAL INFORMATION. -

1. Location, design grade, and loading. - The reinforced concrete flood wall will extend from the end of the wall now under construction and known as the Initial Fiscal Year 1939 Unit, Holyoke, Mass., to 100[±] south of Tailrace Structure No. 10. Tailrace gate structures occur at the following stations: No. 1 at Station 16+75[±], No. 4 at Station 25+90[±], No. 6 at Station 35+60[±], No. 7 at Station 40+83[±], No. 8 at Station 44+30[±], No. 9 at Station 50+10[±], No. 10 at Station 52+90[±], No. 11 at Station 55+90[±], and No. 12 at Station 58+80[±]. Pumping stations will be incorporated as a part of Tailrace Gate Structures Nos. 1, 4, 7 and 10. The structures are designed to resist a principal load coming from the assumed head of water taken from 1.5 to 2.9 feet higher than the walls and therefore somewhat greater than the Comprehensive Plan flood stage. This design head is in accordance with instructions from the Office of the Chief of Engineers. The walls could be raised by temporary breastwork, by sand bags or flash boards at times of extreme flood. In general, the secondary loading is the ground fill on the land side of the walls. The walls vary in height from 8'6" to 37'0".

2. Type of wall. - In general, the "T" type cantilever wall was selected as being the most economical for the height of wall needed under the existing conditions. The sections of the flood wall adjacent to the tailrace structures were of a buttress type due to the necessary

increased height. For some sections of the wall due to local conditions, such as a building obstruction, an "L" type cantilever was used as the most practicable type. Concrete facing walls were used at locations of existing dikes.

3. Tailrace gate structures. - The concrete tailrace structures were designed to resist a load coming from a head of water, equivalent to that used in the design of the walls. The structures were investigated for stability for two conditions of loading: one with the river at flood stage and one with the river down. The conduit portions of the structures were designed as rigid boxes loaded with maximum pressures obtainable.

4. Pumping stations. - In the following design analysis, the pumping stations were considered an integral part of the tailrace gate structures.

B. GENERAL DESIGN DATA. -

1. General. - The structural design of the structures have been executed, in general, in accordance with standard practice. The specifications which follow cover the condition affecting the design for stability, reinforced concrete and structural steel.

2. Unit Weights. - The following unit weights for materials were assumed:

Water 62.5 pounds per cubic foot.
Dry earth 100 pounds per cubic foot.
Saturated earth 125 pounds per cubic foot.
Concrete 150 pounds per cubic foot.
Structural steel 489.6 pounds per cubic foot.

3. Earth pressures. - In computing active earth pressures

equivalent fluid pressures computed by the use of Rankine's formula were used. They are as follows:

Equivalent liquid pressure of dry earth = 35 pounds per cubic foot.

Equivalent liquid pressure for saturated earth = 80 pounds per cubic foot.

In computing passive resistances, Rankine's formula was used with the coefficient of internal friction = 35 degrees.

4. Hydrostatic uplift. -

a. Riverside of sheet piling.

Full head due to headwater.

b. Landside of sheet piling

(1) At landward toe, full head due to tailwater.

(2) At sheet piling, full head due to tailwater

plus one-half the difference between headwater and tailwater.

(3) At intermediate points, the uplift was assumed to vary uniformly with the distance from the toe.

5. Overturning. - The resultant of all external loads, including hydrostatic uplift and excluding base pressure, does not fall within the middle third under every condition but under no condition is the allowable bearing value of the soil exceeded.

6. Sliding. - The total horizontal forces due to external loads shall not exceed the resistance available from friction and passive resistance. The coefficient of friction used is 0.45.

7. Bearing. - The total bearing pressure, equal to the sum of hydrostatic pressure plus the remaining effective base pressure, shall

in no case exceed the maximum allowable soil pressure.

8. Frost cover. - All footing bases shall lie at least 4 feet beneath the ground surface to avoid heaving by frost action.

9. Path of percolation. - Except where steel sheet piling is driven to rock, the minimum path of percolation shall be determined as follows: Wall with sheet pile cutoff and with filter on landside five times the head of water for wall with stem up to 5'0" above the base and four times the head of water with stem greater than 5'0" above the base.

10. Reinforced concrete. - In general, all reinforced concrete was designed in accordance with the "Joint Code of the American Concrete Institute and the Reinforcing Steel Institute for the Design of Concrete and Reinforced Concrete" issued in 1928 and the "Progress Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete" issued in January 1937.

a. Allowable stresses. - The allowable working stresses in concrete are based on an average ultimate compressive strength in 28 days of 3,400 pounds per square inch for Class "A" concrete and 3,000 pounds per square inch for Class "B" concrete.

b. <u>Flexure (f_c).</u> -	<u>Lbs. per sq. in.</u>
Extreme fibre stress in compression	800
Extreme fibre stress in compression	
adjacent to supports of continuous or fixed beams or	
rigid frames	900

Lbs. per sq. in.

c. Shear (v). -

Beams with no web reinforcement and without special anchorage	40
Beams with no web reinforcement but with special anchorage of longitudinal steel	60
Beams with properly designed web re- inforcement and with special anchorage of longitudinal steel	180
Footings where longitudinal bars have no special anchorage	40
Footings where longitudinal bars have special anchorage	60

d. Bond (u). -

In beams, slabs and one way footings	100
Where special anchorage is provided	200
The above stresses are for deformed bars.	

e. Bearing (f_c). -

Where a concrete member has an area at least twice the area in bearing	500
---	-----

f. Steel stresses. -

Tension	18,000
Web reinforcement	16,000

g. Protective concrete covering. -

<u>Type of members</u>	<u>Minimum cover in inches</u>
Interior slabs	1-1/2

<u>Type of members</u>	<u>Minimum cover in inches</u>
Interior beams	2
Members poured directly against the ground	4
Members exposed to earth or water but poured against forms	3

For secondary steel, such as temperature and spacer steel, the above minimum cover may be decreased by the diameter of the temperature or spacer steel rods.

C. BASIC ASSUMPTION FOR DESIGN. -

1. Tailrace gate structures. -

a. Stability. - The stability of the gate structures as a unit was investigated for the worse conditions of loading, namely, with the river at flood stage and also with the river at low stage. In all conditions of loading, the base pressures were held below the allowable.

b. Roof slabs of pump houses. - The roof slabs are of reinforced concrete. They were designed to carry the full dead load plus a live load of 40 pounds per square foot of roof surface.

c. Machinery room floors. - The machinery room floors were designed to carry all motors, etc., actually to be placed on that floor as well as a uniform load.

The following assumptions were made for design purposes:

(1) For the floor slab, the design loads were the estimated dead load plus a uniform load of 350 pounds per square foot.

(2) For removable steel floor plates, the design loads were the estimated dead load plus a uniform load of 350 pounds per square foot.

(3) For the floor beams the design loads were the estimated dead loads on the unoccupied portion of the floor slabs which contribute loads to the beams under consideration. For the machinery loads an impact factor of 100 per cent has been added.

d. Pump room side walls and floor slab. - In designing the pump room side walls and floor slabs, the assumption was made that the side walls, above the machinery floor, are simply supported at the top edges and fixed at the base.

e. Sumps. - The pumping station sumps were designed as closed horizontal rectangular frames continuous at all four corners, except for the portions included in the depth of the sump sluice gate openings. These portions were designed as horizontal frames hinged on each side of the sluice gate openings. The sump floor slabs and the extensions of these slabs to the landside of the structures were designed for the net upward reactions against them as well as for the gravity loads which they are to support. The slabs were assumed as simply supported except where conditions justified assumptions of continuity.

f. Conduits. - The conduit portions of the tailrace structures were designed as rigid frames to carry the maximum possible loads from earth cover, horizontal earth thrust and maximum base pressure.

g. Walls. -

(1) The rear wall was designed to resist an earth load from the fill on the landside and also a water load from the riverside.

(2) The front curtain wall was designed to resist an ice pressure of 1,000 pounds per square foot assumed to act over two feet giving a loading of 500 pounds per foot.

h. Buttresses. - The buttresses were designed as cantilever beams carrying a load of one-half the span of the conduit.

2. Flood walls. - The reinforced concrete flood walls were assumed to act as cantilever walls, resisting lateral forces in both directions. The restraint of the sheet piling was neglected.

a. Wall stem. - The stem was designed as a cantilever beam fixed at the top of the base support to carry the differential load due to water pressure and earth pressure. The landside face of the stem was designed to carry the load from the backfill or railroad for those sections of the wall where these loads exist.

b. Base slab. - Both riverside and landside footings were designed as cantilever beams fixed at the face of the stem.

3. Wing walls at gate structures. - The reinforced concrete wing walls were assumed to act as buttress walls, resisting lateral forces in both directions. The restraint of the sheet piling is neglected.

a. Wall stem. - The stem was designed to carry the differential load due to water pressure and earth pressure by beam action to the buttresses.

b. Landside base slab. - The landside footings were

designed as beams simply supported at the buttresses, due to the "stepping up" of the bases adjacent to the structure.

c. Riverside base slab. - The riverside footings were designed as cantilever beams supported at the face of the stem.

d. Buttresses. - The buttresses were designed to resist the compressional tensional and shearing forces induced by the slabs.

VIII. CONSTRUCTION PROCEDURE

VIII. CONSTRUCTION PROCEDURE

A. SEQUENCE OF OPERATIONS. - It is assumed that construction operations will start about June 25, 1939. It is expected that the total construction work will be completed within 450 calendar days or by September 10, 1940. The work may be divided into numerous areas and sections. It is desirable to finish all the work from the upstream end of the job to the No. 2 Wasteway during the first season construction. However, as many of the structures, downstream from No. 2 Wasteway, should be built as is possible during the first construction season. During the second season the remaining gate structures, walls and dike shall be completed. No work will be permitted on the earth dike during freezing weather. No concrete work will be permitted between November 15, 1939, and March 15, 1940, without adequate cold weather protection.

B. STAGE HYDROGRAPHS. - Stage hydrographs covering the past 20 years are given on Plates No. 10 and No. 11 for the information and guidance of the contractor. These hydrographs were plotted from records kept at the Gill Paper Company and have been stage related to two other gages in the zone of construction, located at the Municipal Gas Company and at the Crocker Division of the American Writing Paper Company. These gages are located on Plate No. 11.

C. CONSTRUCTION SCHEDULE. - It is proposed to have the construction work adhere as near as possible to the following schedules:

Item	:No. of :Working Days:	: Unit :	: Quantity :	: Daily Rate
Excavation	: 200	: cu. yd.:	: 60,000	: 300 cu. yd.
Steel sheet piling	: 200	: sq. ft.:	: 136,000	: 680 sq. ft.
Concrete	: 190	: cu. yd.:	: 21,850	: 115 cu. yd.
Earth dike	: 20	: cu. yd.:	: 4,400	: 220 cu. yd.

CONSTRUCTION SCHEDULE

June 25, 1939 to September 10, 1940 -- 450 Calendar Days.

Construction Unit	Designation	Time Limits	No. of Wks	Concrete Quantities
Structure (1)	Tailrace No. 1 & No. 2	1939 June 25 - Sept. 1	60	870 c.y.
Structure (1)	Tailrace No. 4	1939 July 1 - Oct. 15	60	700 c.y.
Stop-log (3)	Tailrace No. 5	1939 Sept. 1 - Nov. 1	20	200 c.y.
Structure (4)	Tailrace No. 6 and wingwall (Mono-lith)	1939 Aug. 15 - Nov. 1	60	730 c.y.
Structure (4)	Tailrace No. 7	1939 July 25 - Oct. 1	60	1100 c.y.
Structure (4)	Tailrace No. 8	1940 July 1 - Sept. 1	40	430 c.y.
Structure (4)	Tailrace No. 9	1940 May 15 - July 15	40	430 c.y.
Structure (1)	Tailrace No. 10	1940 July 1 - Sept. 1	50	1000 c.y.
Structure (4)	Tailrace No. 11 and wingwalls	1939 June 25 - Sept. 1	50	1120 c.y.
Structure (1)	Tailrace No. 12 and wingwalls	1940 May 15 - Aug. 15	60	1280 c.y.
Stop-log (3)	Stop-log No. 1	1939 June 25 - Aug. 1	30	85 c.y.
Structure (1)	Stop-log No. 2	1939 Aug. 1 - Sept. 1	20	40 c.y.
Stop-log (3)	Stop-log No. 3	1939 Aug. 1 - Sept. 1	20	60 c.y.
Stop-log (3)	Stop-log No. 4	1939 Sept. 1 - Nov. 1	40	220 c.y.
Stop-log (3)	Stop-log No. 5	1940 Mar. 1 - May 1	40	270 c.y.
Wall (2)	Wall-Stop-log No. 1-upstream	1939 June 25 - Aug. 15	40	1440 c.y.
Wall (2)	Wall-Stop-log No. 1-Tailrace No. 1	1939 Aug. 15 - Nov. 1	40	1360 c.y.
Structure (1)	Wall-Stop-log No. 2 - 1st level canal	1939 Sept. 1 - Oct. 1	20	330 c.y.
Structure (1)	Wall-2nd level canal - Stop-log No. 3	1939 Oct. 1 - Nov. 1	20	480 c.y.
Wall (2)	Wall-Stop-log No. 3-Tailrace No. 4	1940 Mar. 1 - Apr. 1	20	300 c.y.
Wall (2)	Wall-Tailrace No. 4 - Bridge	1940 Apr. 1 - June 15	40	1150 c.y.
Wall (2)	Wall-Bridge-Stop-log No. 5	1940 June 15 - Aug. 1	30	800 c.y.
Wall (2)	Wall-Stop-log No. 5 - Tailrace No. 7	1940 July 1 - Sept. 1	40	1340 c.y.
Stop-log (3)	Wall-Tailrace No. 7 - Tailrace No. 8	1940 May 1 - July 1	40	1480 c.y.
Stop-log (3)	Wall-Tailrace No. 8 - Tailrace No. 9	1940 July 1 - Sept. 1	40	2720 c.y.
Structure (4)	Wall-Tailrace No. 9 - Tailrace No. 10	1940 Aug. 1 - Sept. 1	20	1030 c.y.
Structure (1)	Wall-Tailrace No. 10 - Dike	1940 Aug. 1 - Sept. 1	20	500 c.y.
Structure (1)	Embankment - Dike	1940 Aug. 1 - Sept. 1	20	(Earth) 4400

The permanent steel sheet pile will be driven so as to keep ahead of the concrete construction. The drainage system will be built during and following the wall construction and before the dike construction. Installation of equipment will be started as soon as possible in the finished structures.

Two transformer stations are to be installed, one at each end of the project. (See Plate No. 24.) Erection of the upstream station will be completed and in operation at the end of the first construction period to aid in the complete flood protection of the area upstream of No. 2 Wasteway. Completion of the downstream station and all interconnections (see Section VI B 3) will be accomplished during the second working season.

1. Requirements to be met. - The work shall be carried on at such places and in such order as to meet the following requirements relative to the time of shutdown of the various tailraces:

a. Tailraces No. 1 and No. 2. - Both can be shut down at the same time. Neither to be shut down at the same time as Tailrace No. 12.

b. Tailrace No. 4. - Has no relation to the other tailraces.

c. Tailrace No. 6. - Has no relation to the other tailraces.

d. Tailrace No. 7. - Not to be shut down at the same time as Tailraces No. 1 or No. 2.

e. Tailrace No. 8. - Not to be shut down at the same time as either Tailraces No. 11 or No. 12.

f. Tailraces No. 9 and No. 10. - Have no relation to the other tailraces.

g. Tailraces No. 11 and No. 12. - Only one of these to be shut down at a time.

Further discussion of the shutdown period requirements will be found in Paragraph D 6 of this Section VIII.

D. CONSTRUCTION DETAILS

1. Foundation preparation. - This phase of work will consist of all stripping, excavation, sheeting and attendant necessary work to prepare the foundations for the respective structures. In the case of the tailrace structures, the work also will include temporary cofferdams. Track adjustments will be done by the New York, New Haven and Hartford Railroad Company, excepting the sub-base, bridge and trestle work required, which will be done by the contractor. Foundation excavation shall not proceed too far ahead of the concrete construction.

2. Steel sheet piling. - Driving of the steel sheet piling will be done before the concrete is placed. Driving of the steel sheet piling under the railroad tracks will be effected with the least amount of traffic interruptions. The steel sheet piling will also be in place before the construction of the dikes begins.

3. Concrete structures. - The flood wall will be constructed in sections approximately 40 feet long. In general, two pours will be allowed, one for the base and one for the stem. The tailrace structures will be built with regard to a minimum interference with industrial plant operations in the affected areas. The stop-log structures will be built so as to minimize railroad traffic interruption. Copper water stops will be used in all expansion joints to effect a continuous watertight protection. Back filling will follow the construction as close as possible, but will not be done in freezing weather.

4. Dike construction. - The earth dikes are a very small part of the project and will be constructed during the second season. Impervious and random fill materials will be obtained from excavations and from approved borrow areas. The dikes will be built by the rolled fill method. The fill will be placed by truck or crawler wagons and rolled by sheepsfoot, cylindrical or disc rollers, as may be required. The slopes will be sodded and seeded when finished.

5. Installation of equipment. - As soon as possible, during and after construction of the tailrace structures, the gates, pumps, motors, valves, piping, switchboard and connections, the lighting system and other equipment furnished by the Government will be installed. An attempt will be made to complete, for operation, that section upstream from No. 2 Wasteway during the first construction season.

6. Local conditions and requirements. - During construction, it is impossible to avoid shutting down the various tailraces for a short period of time. To do this and to operate, the various plants must get their power supply from other sources. To cooperate in shutting down the tailraces the various plants have submitted the following entailed costs per day:

<u>Tailraces and Plant</u>		<u>Cost per day of shutdown</u>
1 and 2	Parsons Div. - A.W.P. Co.	\$231
3	Holyoke Water Power Co.	No cost
4	Holyoke Municipal Plant	No cost
5	Holyoke Water Power Co.	No cost
6	Valley Paper Co.	200-240

Tailraces and plantCost per day of shutdown

7	Crocker Div. - A. W. P. Co.	\$260
8	Albion Div. - A. W. P. Co.	113
9	Mt. Tom Div. - A. W. P. Co.	61
10	Nonotuck Div. - A. W. P. Co.	79
11	Gill Div.-Upper - A.W.P. Co.	73
12	Gill Div.-Lower - A.W.P. Co.	55

A. W. P. Co. means American Writing Paper Company.

The affected plants in the area were contacted and the following physical and discharge data were obtained:

(See Table on next page)

HOLYOKE DIKE (Above Mosher Street)

Data regarding gate structures and mill tailraces

Gate ;			No. :		Water used :	Time of Shutdown:			
Structure:	Tailrace:	Plants	of :	No. :	in c.f.s. :	(days)			
No. :	No. :		Con- :	of :	Normal :				
			duits:	Gates:	Power :	Process:	Initial :	Final :	Remarks
1	1	Parsons Div., A.W.P.	5	2	130	5	15	8	
	2	" " " "	1		60	0			
4	4	Hadley Mills; also	2	2	0	0	-	-	Not in use but some
		Holyoke W.P. Co.							drainage
*		Holyoke W.P. Co.	1	0	0	0	-	-	Abandoned as tail-
									race - to be plugged
									with 24-inch pipe
6	6	Valley Paper Co.	1	1	425	5	15	8	
7	7	Crocker Div., A.W.P.	3	3	130	0			
					130	0	22	8	
					150	8			
8	8	Albion Div., A.W.P.	2	2	120	0	15	8	
					170	6			
9	9	Mt. Tom Div., A.W.P.	1	1	180	4	8	8	Power discharge nor-
					(530)				mally 180 sec.ft.,
									but increases to
									about 530 sec.ft.
									for emergency power
10	10	Nonotuck Div., A.W.P.	2	2	230	4	8	8	
					0				
11	11	Gill Div., A.W.P.	1	1	190	6(1)	8	8	
12	12	Gill Div., A.W.P.	2	2	125	0			
					0	6	8	8	

Notes: (1) Total 6 c.f.s. for No. 11 and No. 12. Usually supplied by No. 12 penstock but No. 11 would have to supply 6 sec. ft. when No. 12 is shut down.

* No gate structure but tailrace conduit to be plugged, except for 24-inch pipe and valve for drainage.

7. Typical assumed method of construction of tailrace structures. - In order that the industrial plants may continue with water power operation during construction of the tailrace structures, pipe flumes will be connected inside the existing tailrace conduits and extended through the cofferdams. The headgates at the respective plants will be closed during the period required to install the pipe flumes and again when the pipe flumes are removed.

The general construction procedure will be about as follows:

1. Close headgates to the plants connected with the tailrace conduits in question.
2. Complete cofferdam and dewater area enclosed.
3. Place concrete in the structure footings.
4. Install pipe flumes to divert plant discharges.
5. Open headgates.
6. Complete tailrace structure construction.
7. Lose headgates.
8. Remove pipe flumes.
9. Adjust and test flood gates.
10. Remove cofferdam and open headgates.
11. Finish installations and structures.

Data on flumes

<u>Tailrace No.</u>	<u>Length of pipe</u>	<u>Diameter</u>
1	100 feet	8 feet
4	---	---

<u>Tailrace No.</u>	<u>Length of pipe</u>	<u>Diameter</u>
6	100 feet	9 feet
7	300 feet	8 feet
8	200 feet	9 feet
9	200 feet	9 feet
10	100 feet	9 feet
11	100 feet	9 feet
12	100 feet	8 feet

To meet conditions of the proposed construction progress, the following lengths and sizes were used with the understanding that the pipes would be re-used where possible.

<u>Length of pipe</u>	<u>Diameter</u>
300 feet	8 feet
500 feet	9 feet

E. LABORATORY AND FIELD TESTS DURING CONSTRUCTION. -

1. Dike construction. - The Soils Laboratory at Providence, Rhode Island, and the field soils laboratory at Northampton, Massachusetts, will perform the necessary tests to investigate and record the characteristics of the types of soil used in construction. Tests will be performed to determine the classification of soils, water content, density of material in place and compaction characteristics of the borrow material. Supplementary shear and permeability tests will also be made. The dike embankment will consist of two types of material, impervious and random fill. Screened gravel and crushed stone will be used for the toe

drain. The types of materials intended for dike fill, and placement of these materials, will be subjected to close control before and during construction.

2. Concrete construction. - Materials used in the concrete will be tested at the Central Concrete Testing Laboratory, West Point, New York. The field tests will be used principally for the control of the quality of concrete during construction. Facilities will be available for grading the aggregates, designing mixes, making of slump tests and for casting and curing concrete cylinders for compression tests. Cement will be tested by a recognized testing laboratory and results of these tests will be known before the cement is used. Only one brand will be used throughout. Fine and coarse gravel will be obtained from approved commercial sources. The amount of water used for each batch of concrete will be predetermined. It will, in general, be the minimum amount necessary to produce a plastic mixture of the strength specified.

IX. SUMMARY OF COSTS.

IX. SUMMARY OF COSTS

The grand total cost of the Fiscal Year 1939 Section has been estimated at \$1,100,000, which includes 10 per cent for contingencies and 15 per cent for engineering and overhead. This cost has been distributed as follows:-

A. For construction contract bid:-

1. Preparation and excavation for foundations, (including cofferdams and care of water)....	\$ 116,400
2. Permanent steel sheet piling	172,000
3. Concrete structures	530,000
4. Drainage system	37,000
5. Dikes	5,000
6. Miscellaneous	<u>114,600</u>

Total (Fiscal Year 1939 Section Contract) \$1,005,000

B. For equipment to be furnished by the United States

89,000

C. For adjustments to the Railroad by the United States

6,000

GRAND TOTAL COST (Fiscal Year 1939 Section) \$1,100,000

1. The preparation and excavation for foundations include the preparation of site, care and diversion of water and sewerage during construction, common excavation, rock excavation and timber and steel sheeting necessary.

2. Permanent steel sheet piling includes only the steel sheet piling.

3. Concrete structures include the care and support of the

railroad tracks during construction, random backfill, cement, concrete, steel reinforcement and copper water stops.

4. The drainage system includes trench excavation, gravel bedding, random backfill, rock drains, pipes and manholes complete.

5. Dikes include borrow excavation, fill required for embankment, gravel bedding, rock drains, topsoil, sodding and seeding and gravel for top of dike.

6. Miscellaneous includes gravel bedding, random backfill rock fill, riprap, rubble masonry, pumping station features other than concrete, tailrace gates and accessories, tailrace gate hoists, sluice gates and hoists, traveling cranes, girders and side rails, miscellaneous iron and steel other than in the manholes, miscellaneous black steel pipe, electric light system, cables and fibre conduits, pull boxes, installation of equipment and materials furnished by the United States, timber stop logs, gravel for roads, bituminous macadam road surfacing and cleaning up.

7. Equipment furnished by the United States includes pumps, motors, valves, piping, switchboards and two transformer stations.

8. Adjustments to the railroad consists of removing and relaying about 1,400 feet of track as necessitated by the construction work. The work will be done by the railroad and the cost will be paid by the United States.

X. PLATES

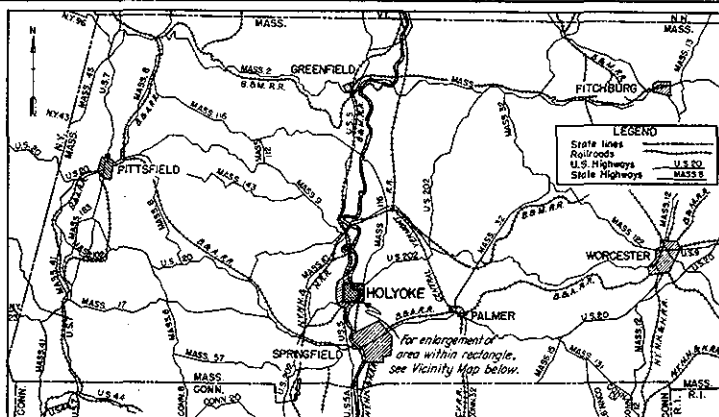
INDEX OF PLATES

Plate No.

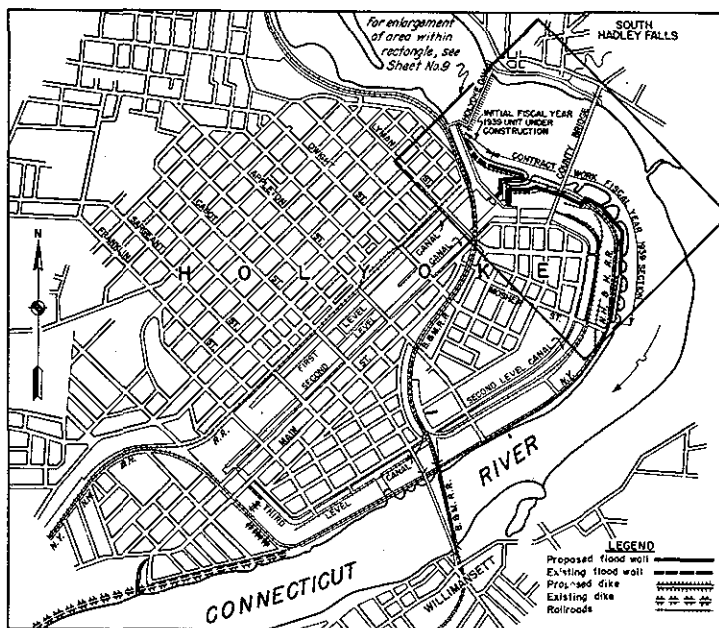
1	Project Location.
2	General Plan.
3	Subsurface Exploration No. 1.
4	Subsurface Exploration No. 2.
5	Subsurface Exploration No. 3.
6	Subsurface Exploration No. 4.
7	Geologic Section.
8	Diagram Showing Limits Of Soil Classes.
9	Borrow Areas.
10	Hydrograph No. 1.
11	Hydrograph No. 2.
12	Analysis Curves Of Typical Materials In Borrow Areas.
13	Compaction Characteristics Of Borrow Materials.
14	Dike Details.
15	Wall Details No. 1.
16	Wall Details No. 7.
17	Wall Details No. 9.
18	Drainage Details No. 1.
19	Drainage Details No. 5.
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- 25 Pumping Station Perspective.
- 26 Tailrace No. 7 - General Plan (Pumping Station No. 3).
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- 28 Circuit Diagram Of Pumping Stations.
- 29 Pumping Capacity Curves For Pumping Station No. 1.
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- 31 Pumping Capacity Curves For Pumping Station No. 3.
- 32 Pumping Capacity Curves For Pumping Station No. 4.
- 33 District Organization Chart.



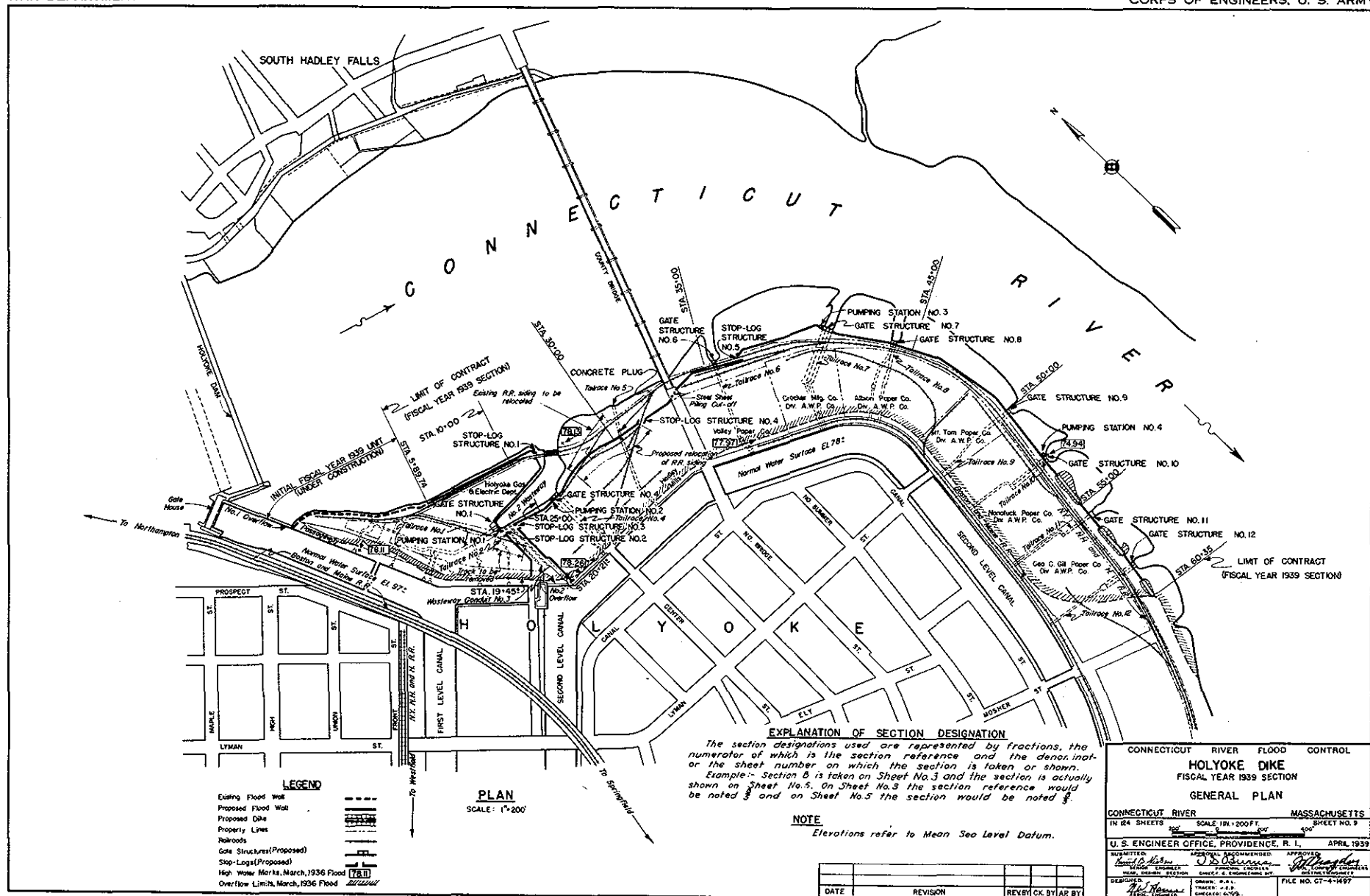
LOCATION MAP
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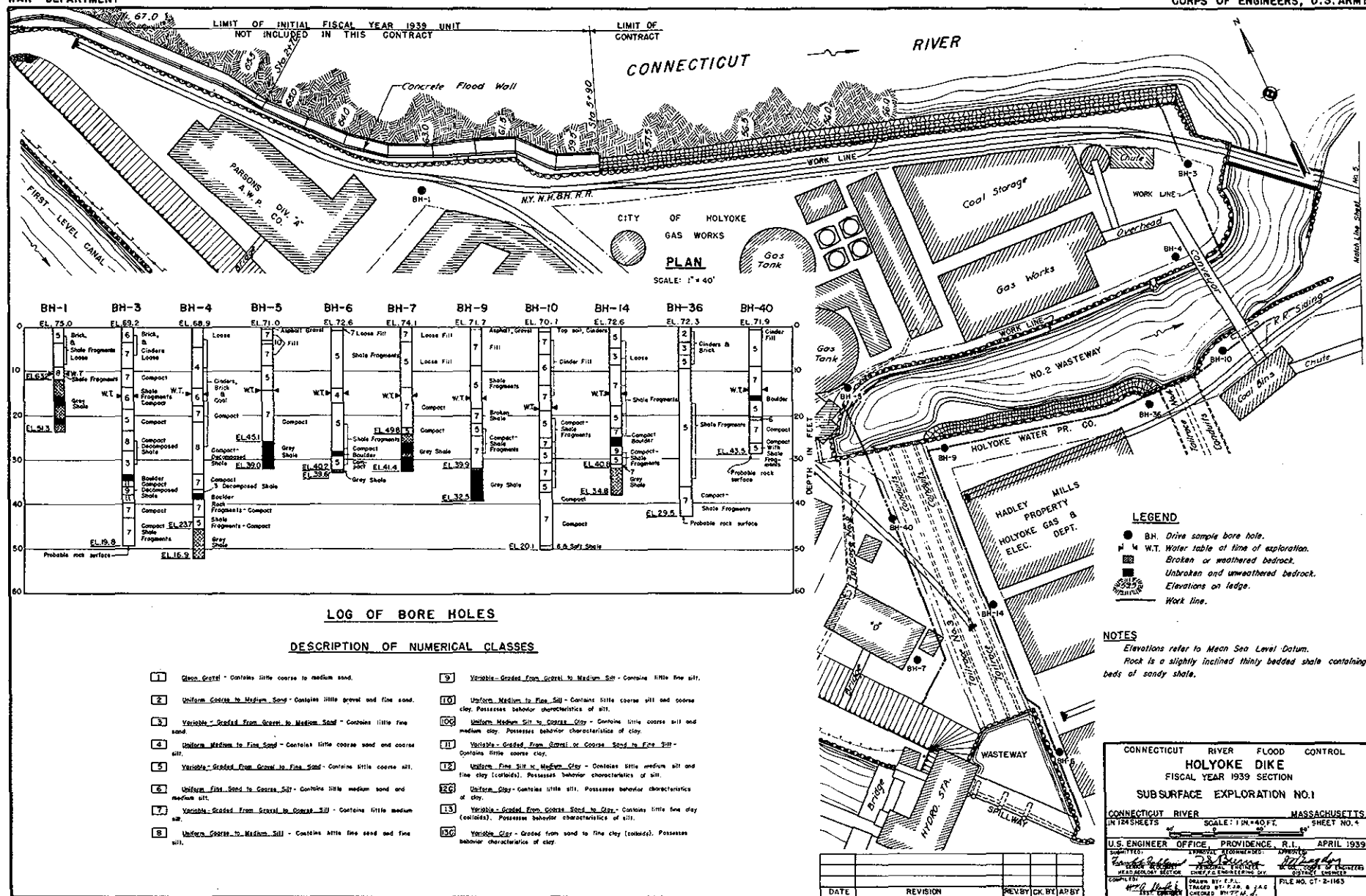


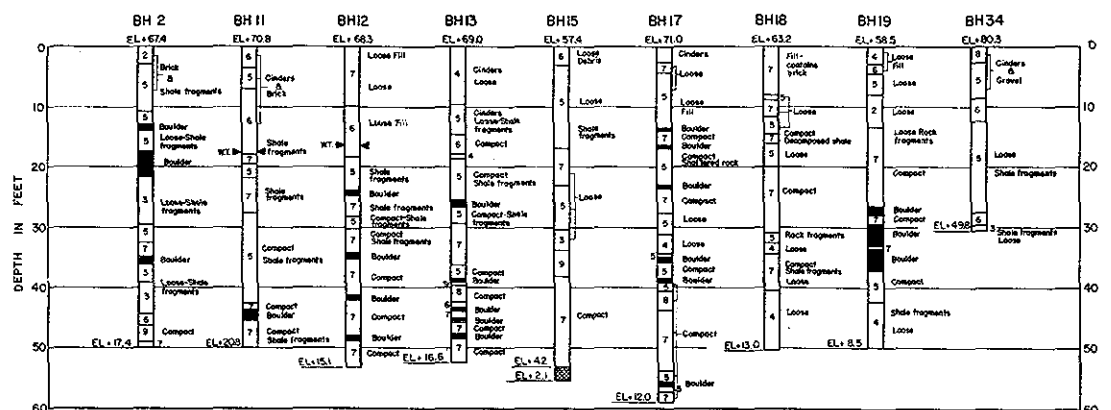
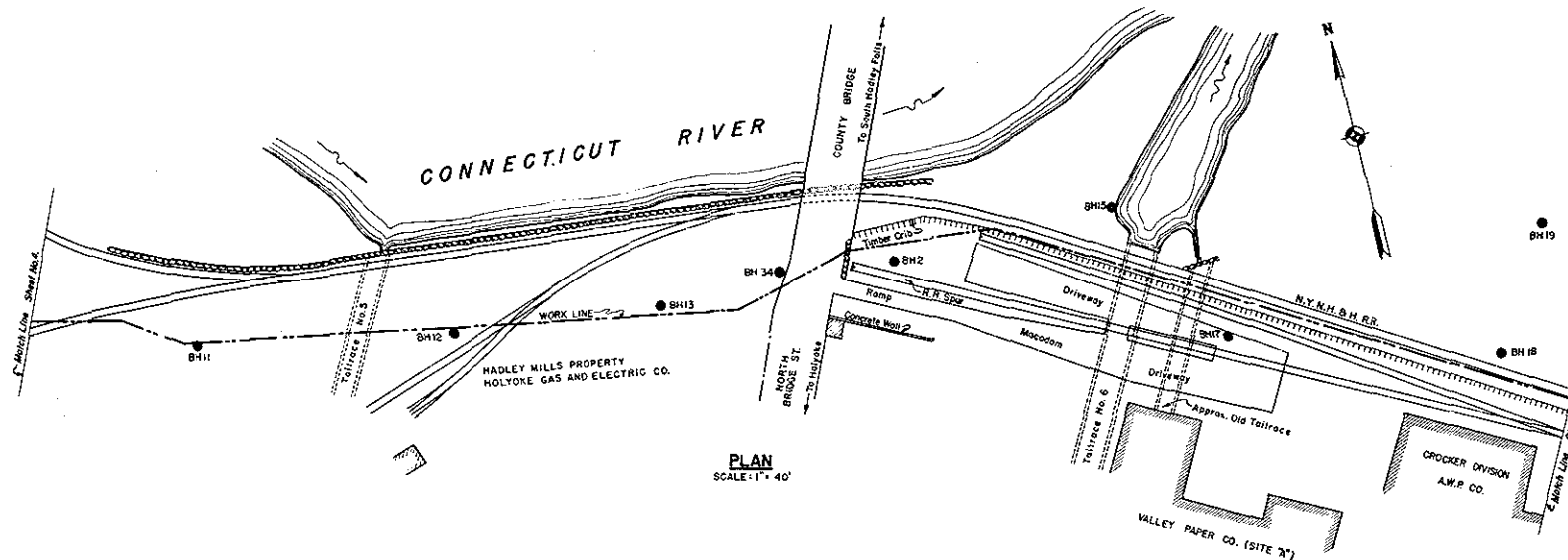
VICINITY MAP
SCALE: 1" = 1000'
0 1000 2000'

CONNECTICUT RIVER FLOOD CONTROL			
HOLYOKE DIKE			
FISCAL YEAR 1939 SECTION			
PROJECT LOCATION AND INDEX			
CONNECTICUT RIVER	MASSACHUSETTS		
1 IN 12 1/2 SHEETS	AS SHOWN	SHEET NO. 1	
U.S. ENGINEER OFFICE, PROVIDENCE, R. I., APRIL 1939			
SUBMITTED	APPROVED	APPROVED	
FOR DESIGN	FOR CONSTRUCTION	FOR CONSTRUCTION	
DESIGNED BY	ENGINEER	CHECKED	
CONSTRUCTED BY	ENGINEER	CHECKED	
FILE NO. CT-4-1496			

DATE	REVISION	PREPARED BY	CHECKED BY	APPROVED BY





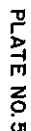


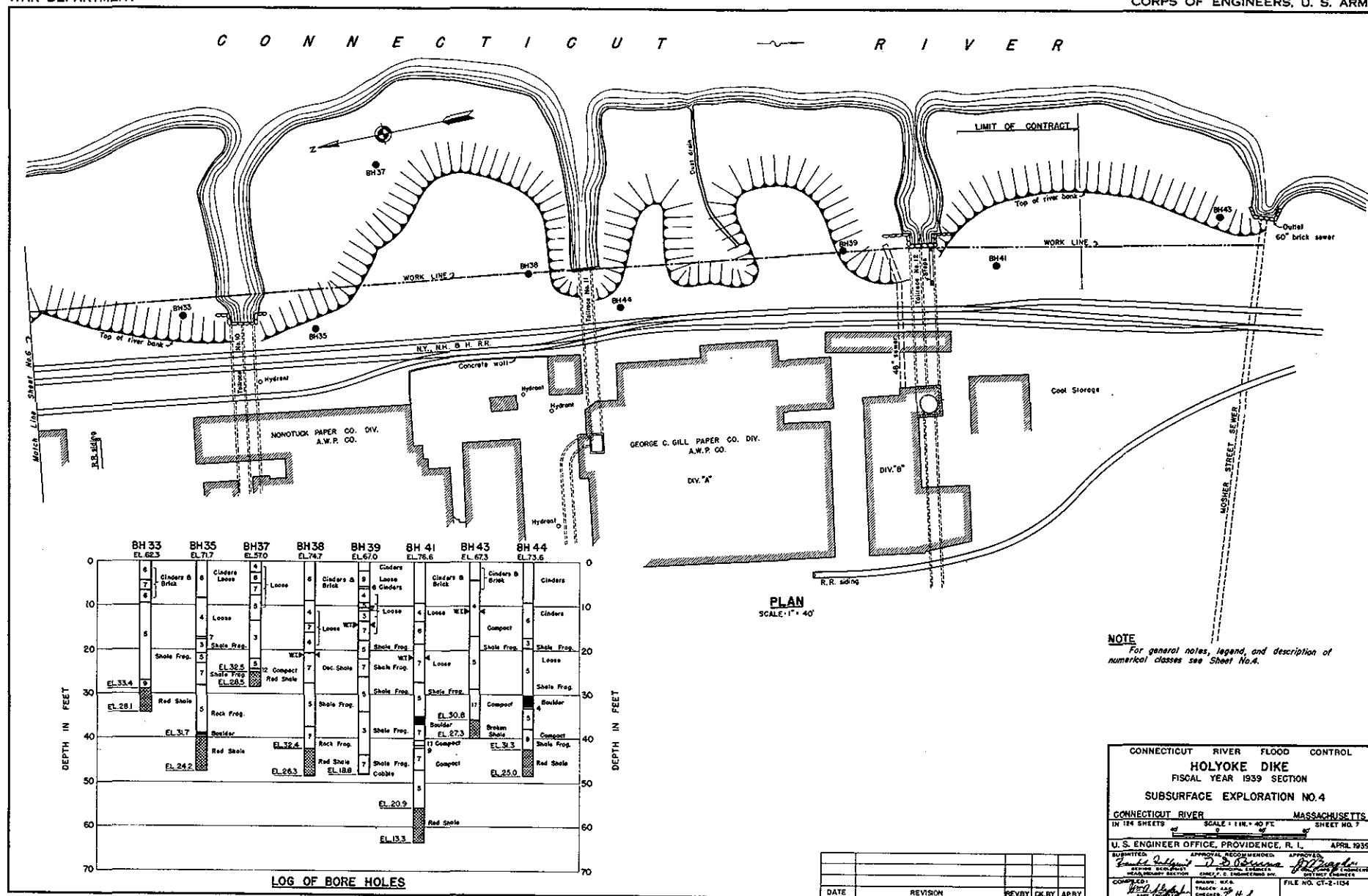
LOG OF BORE HOLES

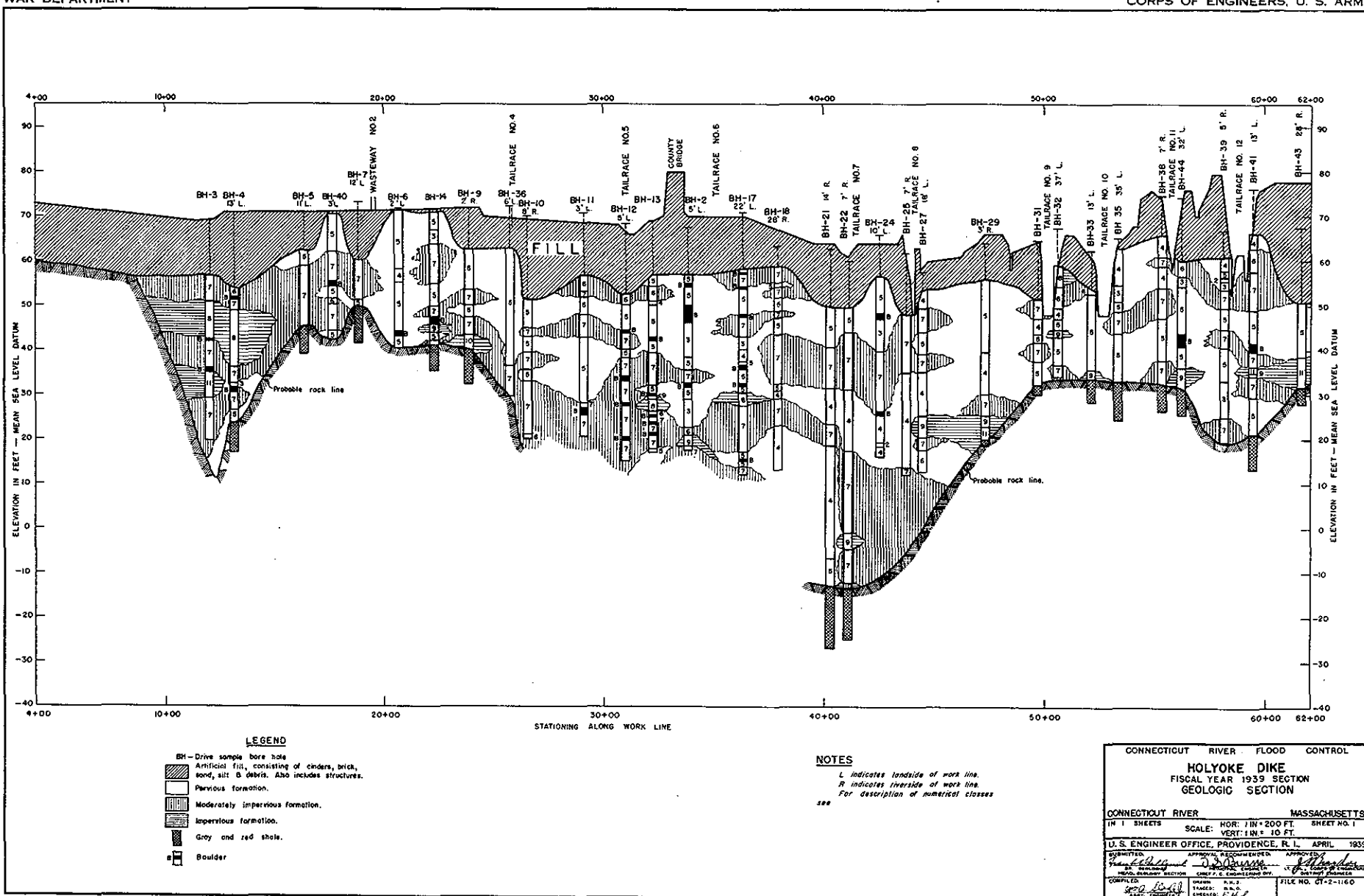
NOTE

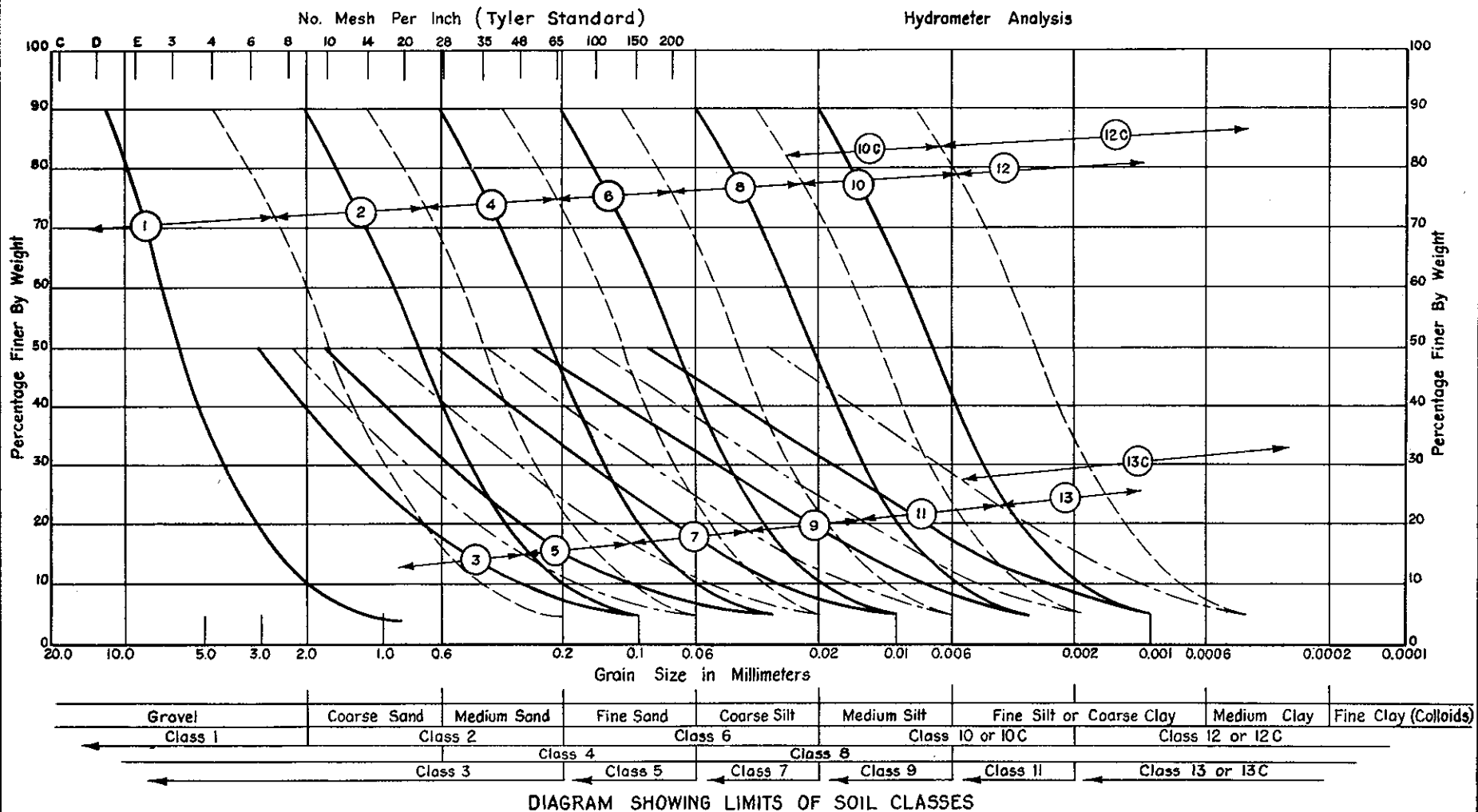
For general notes, legend, and description of numerical classes see Sheet No. 4.

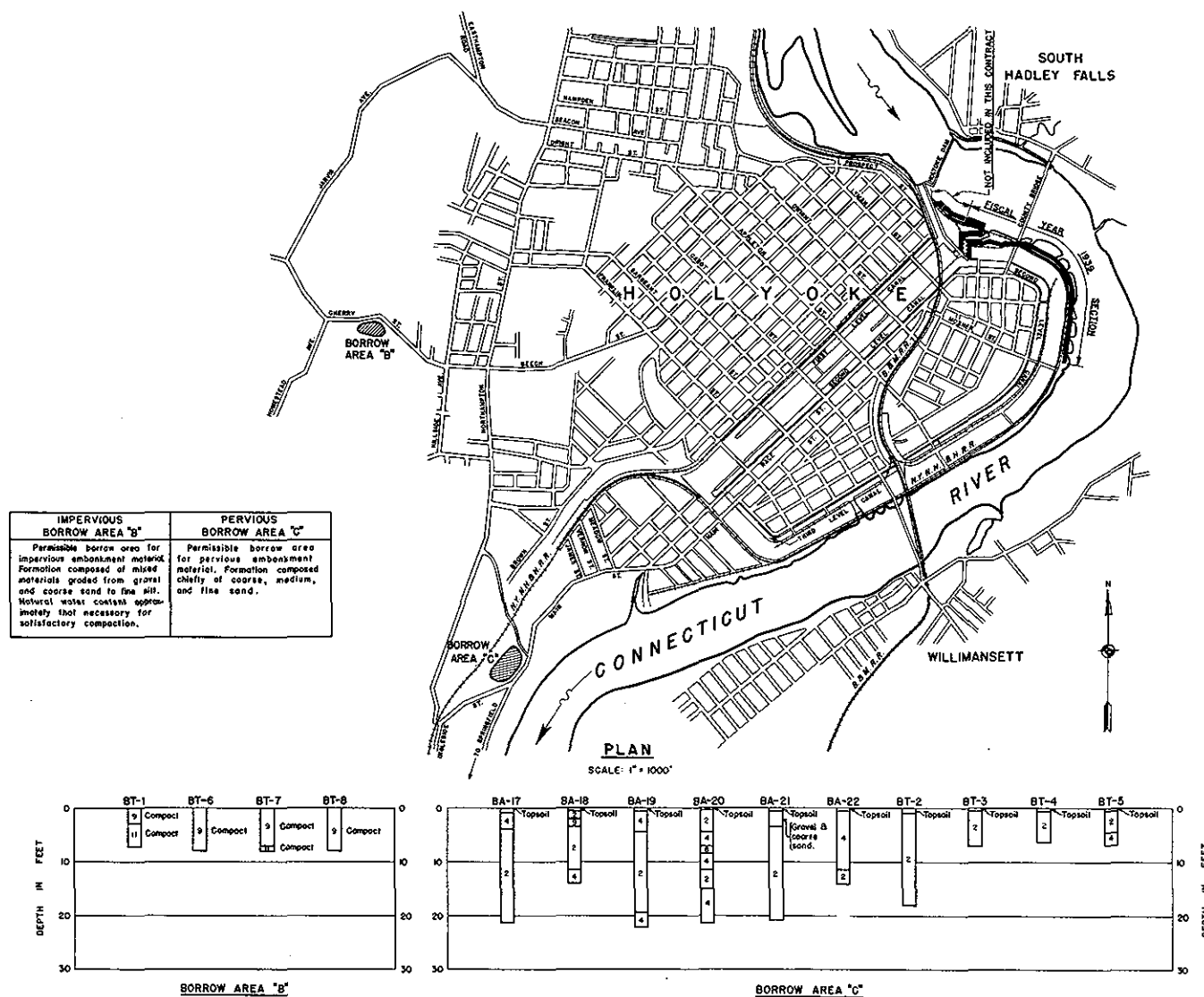
CONNECTICUT RIVER FLOOD CONTROL	
HOLYOKE DIKE	
FISCAL YEAR 1939 SECTION	
SUBSURFACE EXPLORATION NO. 2	
CONNECTICUT RIVER	MASSACHUSETTS
IN 124 SHEETS	SHEET NO. 3
U.S. ENGINEER OFFICE, PROVIDENCE, R. I.	APRIL 1939
DESIGNED BY: <i>Frank S. Dyer</i>	APPROVED: <i>W. H. H. H.</i>
FIELD RECORD: <i>W. H. H. H.</i>	ENGINEER: <i>W. H. H. H.</i>
COMPILED BY: <i>W. H. H. H.</i>	FILE NO. CT-2-1132









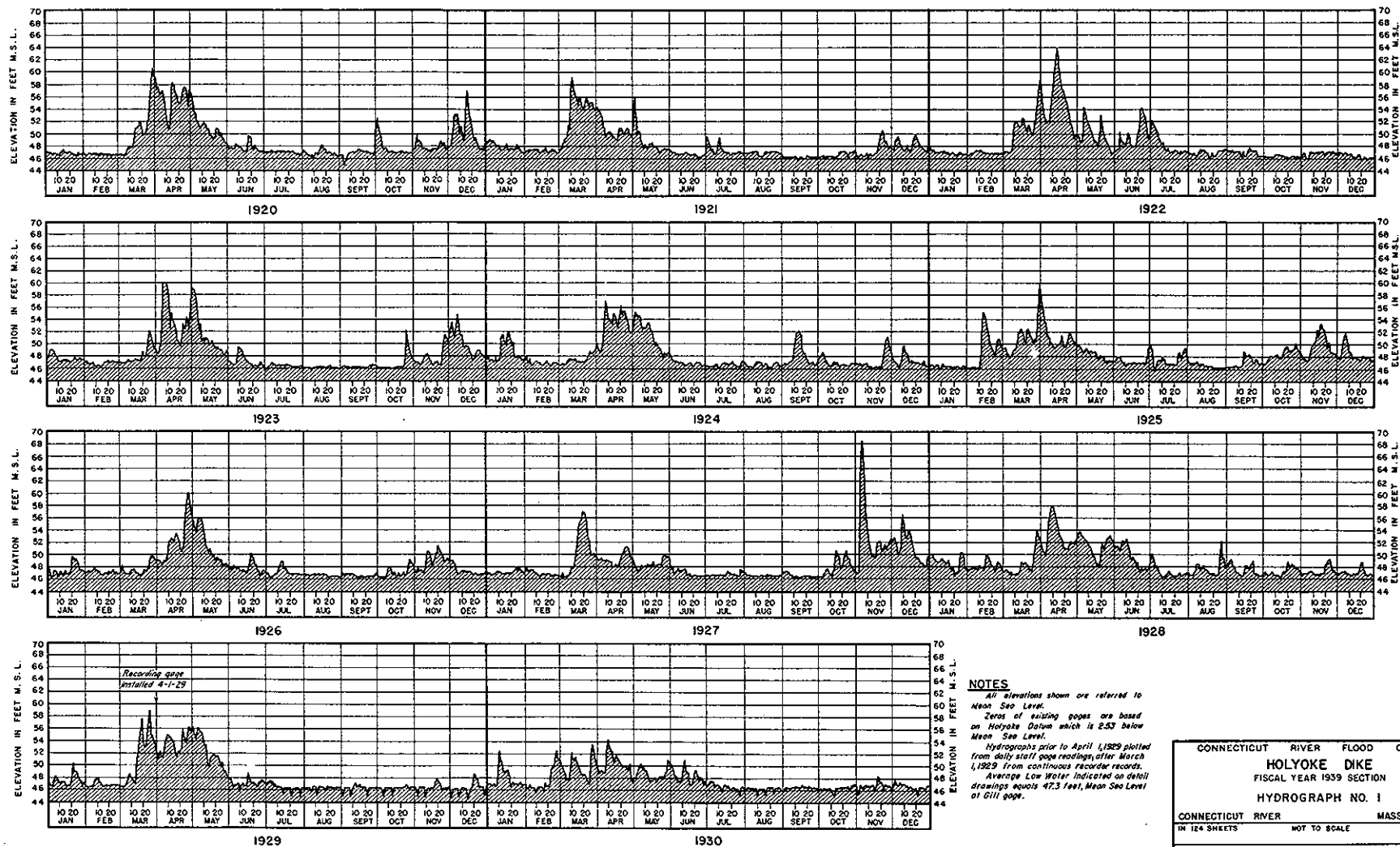
**NOTES**

For description of numerical classes see Sheet No. 4.
BA indicates auger boring.
BT indicates test pit.

RECORD OF BORROW AREA EXPLORATIONS

DATE	REVISION	REV BY	CHK BY	AP BY

CONNECTICUT RIVER FLOOD CONTROL	
HOLYOKE DIKE	
FISCAL YEAR 1939 SECTION	
BORROW AREAS	
CONNECTICUT RIVER	MASSACHUSETTS
4124 SHEETS	SHEET NO. 8
SCALE: 1 IN. = 1000 FT.	2000'
U.S. ENGINEER OFFICE, PROVIDENCE, R.I.	
DATE: APRIL 1939	APPROVED: [Signature]
DESIGNED BY: [Signature]	CHECKED BY: [Signature]
FILE NO. CT-2-1164	



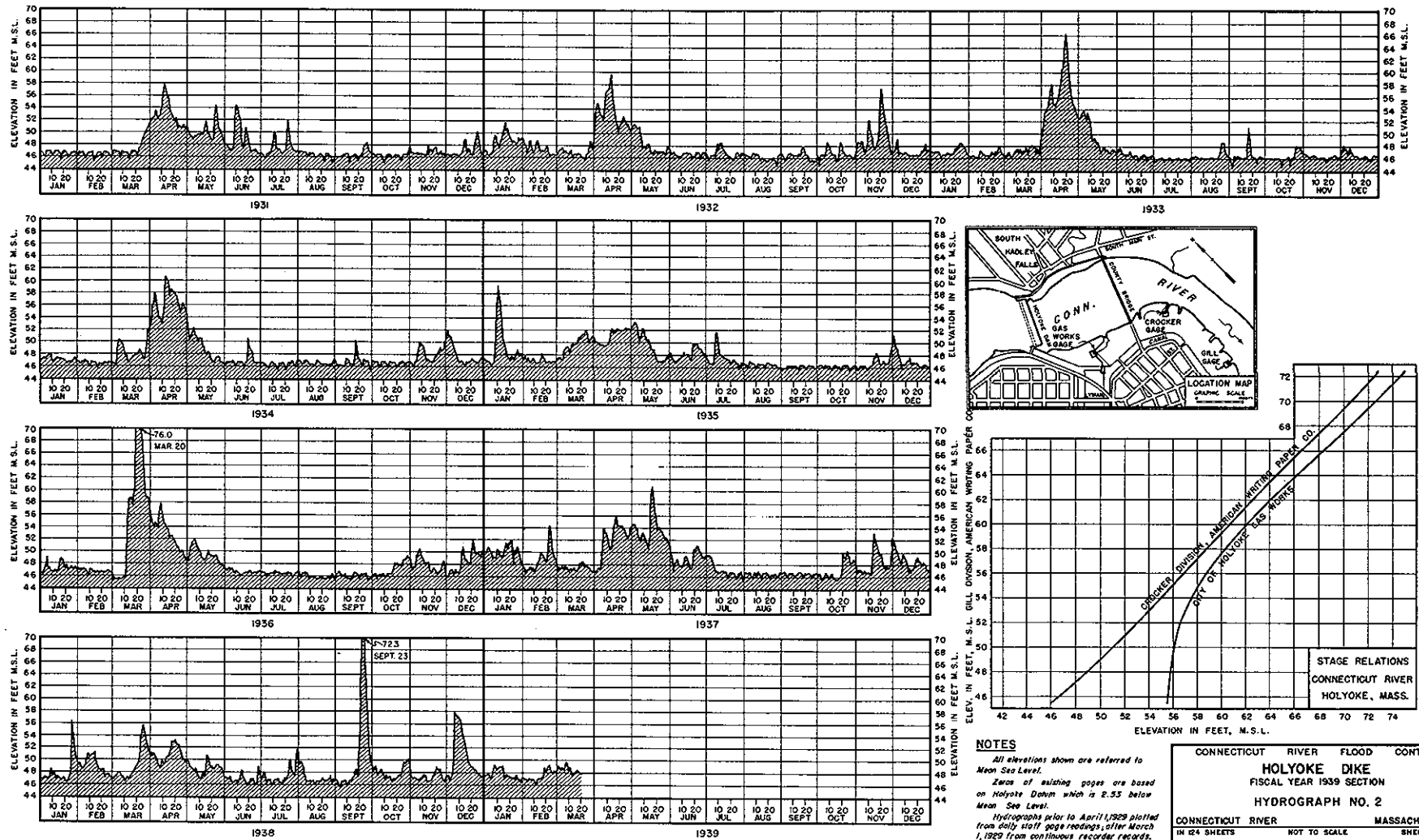
NOTES

All elevations shown are referred to Mean Sea Level.
Zeros of existing gages are based on Holyoke Datum which is 2.53 below Mean Sea Level.
Hydrographs prior to April, 1929 plotted from daily staff gage readings; after March, 1929 from continuous recorder records.
Average Low Water indicated on detail drawings equals 47.3 feet, Mean Sea Level at Gill gage.

RECORD OF ELEVATIONS AT GILL DIVISION-AMERICAN WRITING PAPER COMPANY

DATE	REVISION	REVIEW	OK BY	AP BY

CONNECTICUT RIVER FLOOD CONTROL	
HOLYOKE DIKE	
FISCAL YEAR 1939 SECTION	
HYDROGRAPH NO. 1	
CONNECTICUT RIVER	MASSACHUSETTS
IN 124 SHEETS	SHEET NO. 2
U. S. ENGINEER OFFICE, PROVIDENCE, R. I. APRIL 1939	
APPROVED	APPROVED
<i>John B. Drake</i>	<i>J. S. Brown</i>
HEAD, HYDROGRAPH SECTION	CHIEF, S. ENGINEERING
COMPILED	FILED
<i>John B. Drake</i>	<i>John B. Drake</i>
CHIEF, HYDROGRAPH SECTION	CHIEF, S. ENGINEERING
FILE NO. CT-3-1095	



RECORD OF ELEVATIONS AT GILL DIVISION—AMERICAN WRITING PAPER COMPANY

NOTES

All elevations shown are referred to Mean Sea Level.

Zeros of existing gages are based on Holyoke Datum which is 2.55 below Mean Sea Level.

Hydrographs prior to April 1, 1929 plotted from daily staff gage readings; after March 1, 1929 from continuous recorder records.

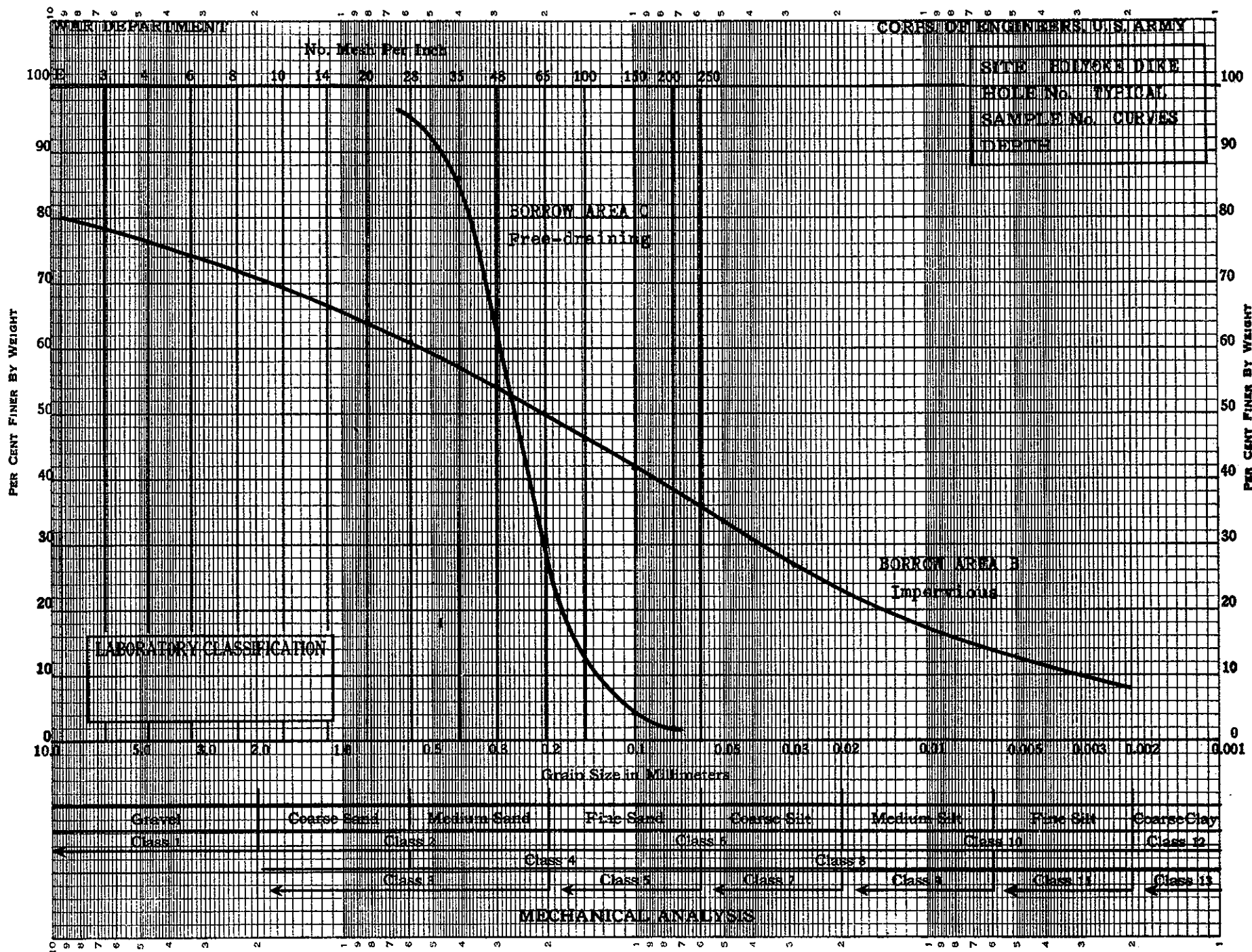
Average Low Water indicated on detail drawings equals 47.3 feet, Mean Sea Level of Gill gage.

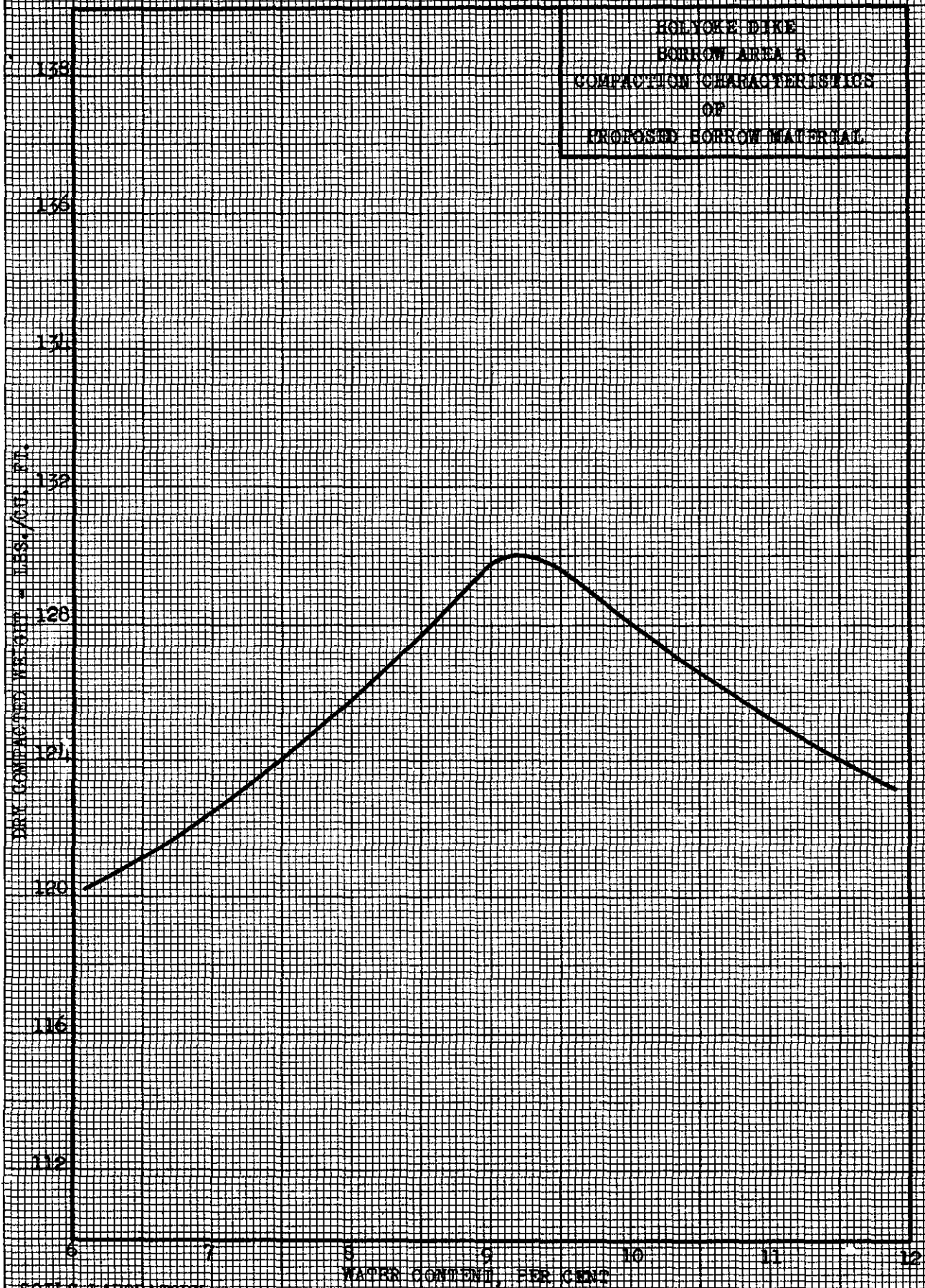
CONNECTICUT RIVER FLOOD CONTROL
HOLYOKE DIKE
 FISCAL YEAR 1939 SECTION
HYDROGRAPH NO. 2

CONNECTICUT RIVER MASSACHUSETTS
 IN 24 SHEETS NOT TO SCALE SHEET NO. 3

U. S. ENGINEER OFFICE, PROVIDENCE, R. I., APRIL 1939

DESIGNED BY: *J. B. [Signature]* APPROPRIATE RECOMMENDED: *[Signature]*
 CHECKED BY: *[Signature]* ENGINEER: *[Signature]*
 COMPILED BY: *[Signature]* DRAWN: L. G. L. FILE NO. DT-3-1088
 CHECKED: *[Signature]*

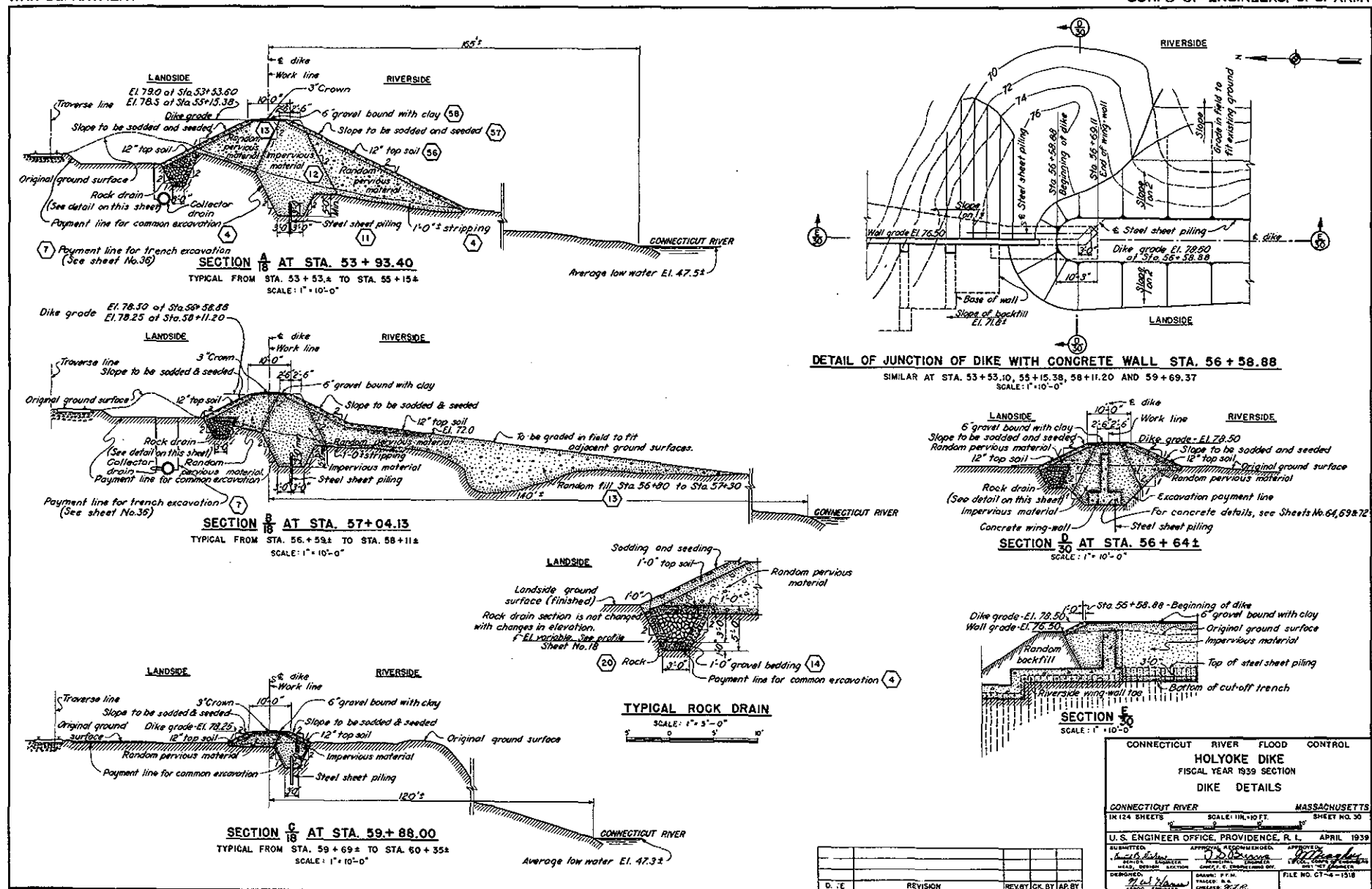


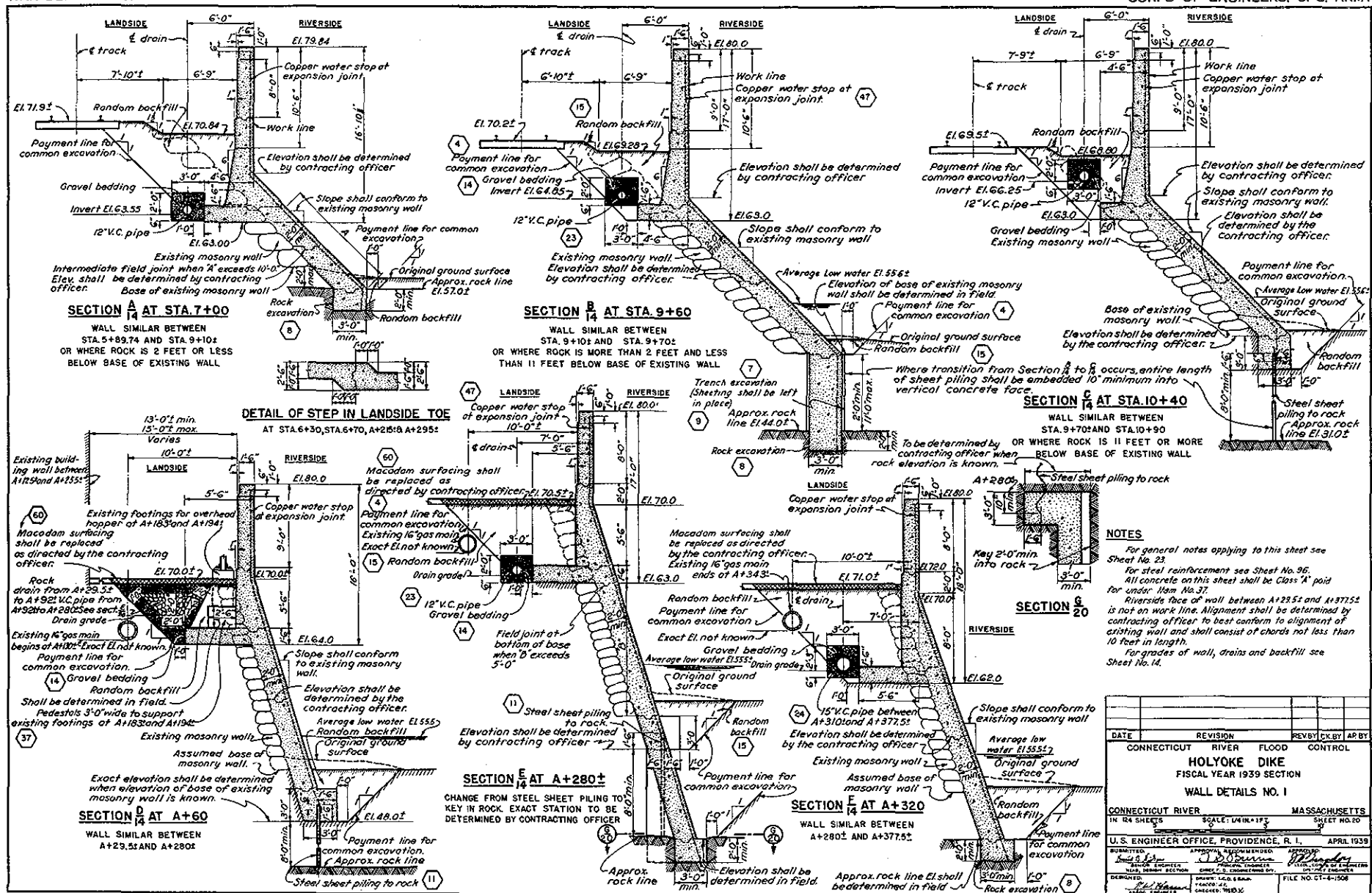


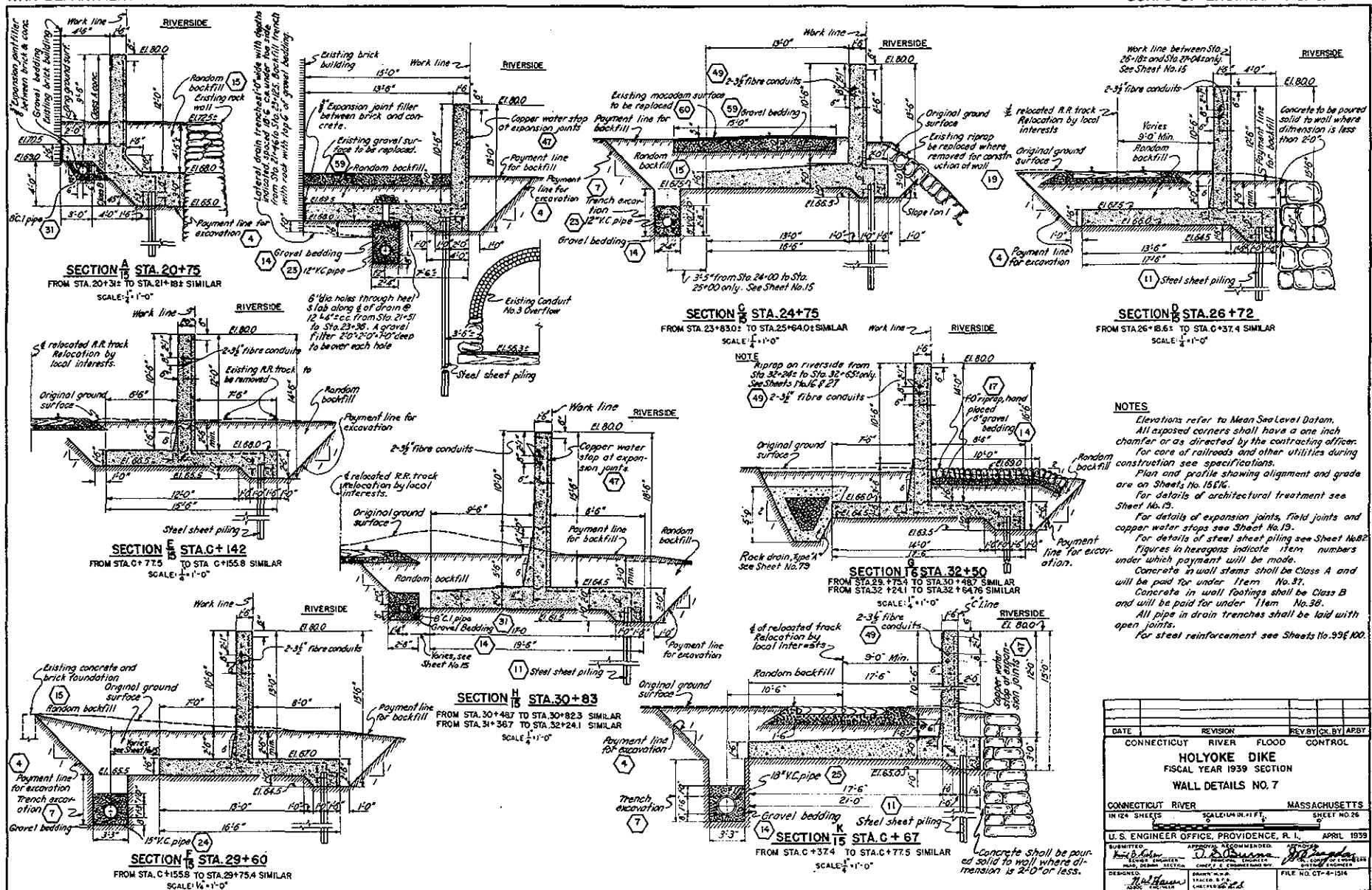
SOILS LABORATORY

PROVIDENCE, R. I.

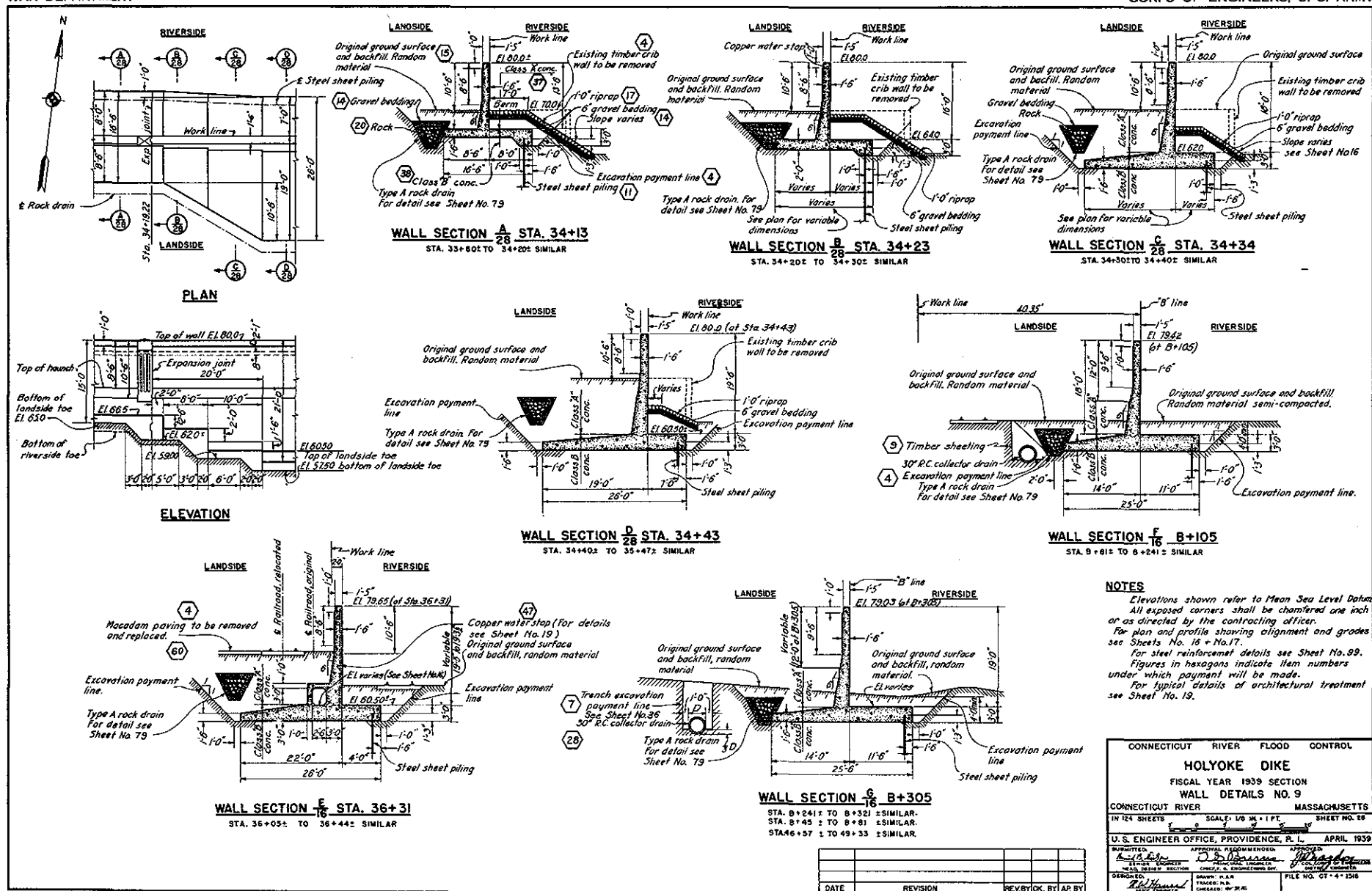
PLATE NO.13

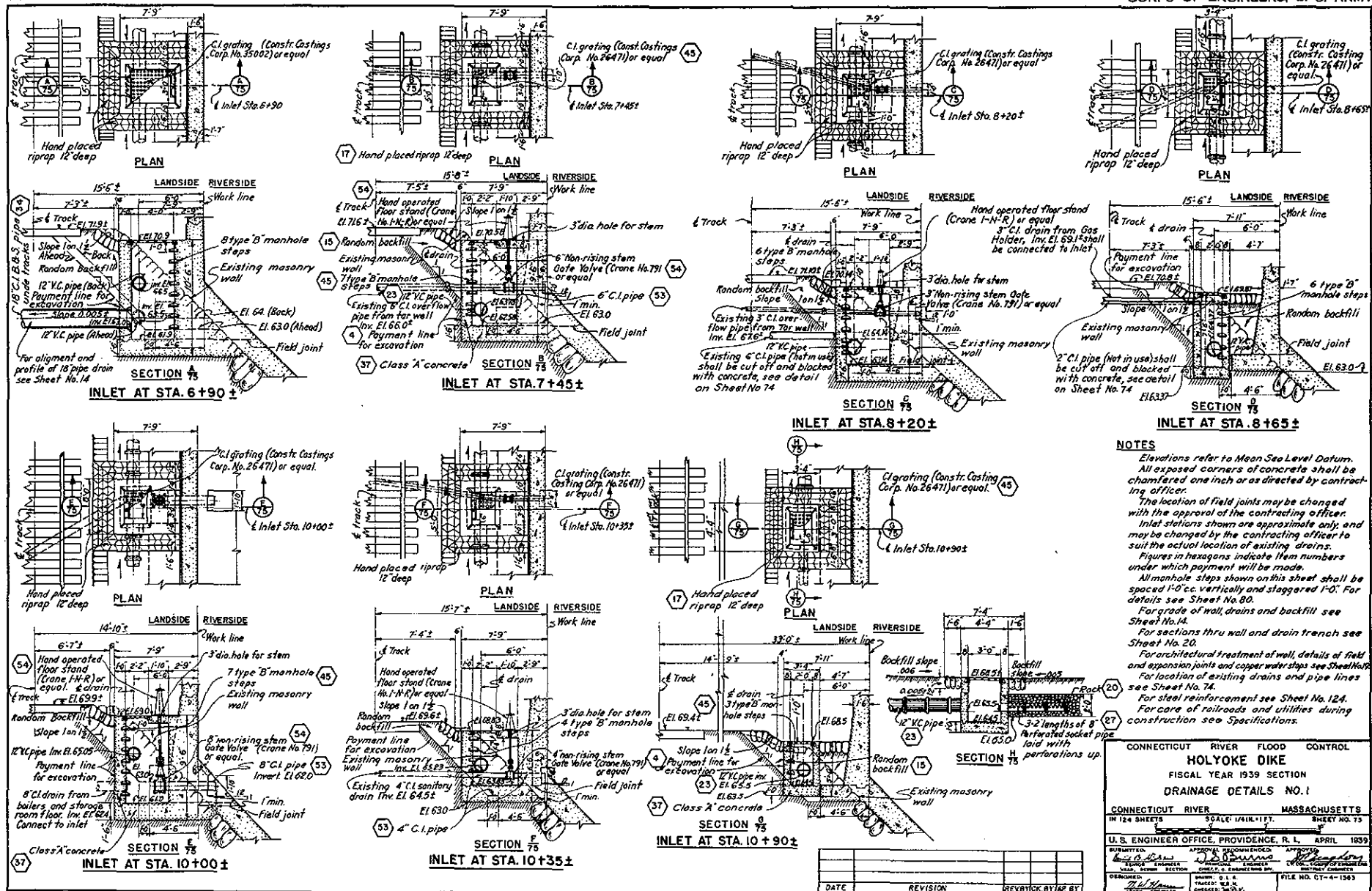


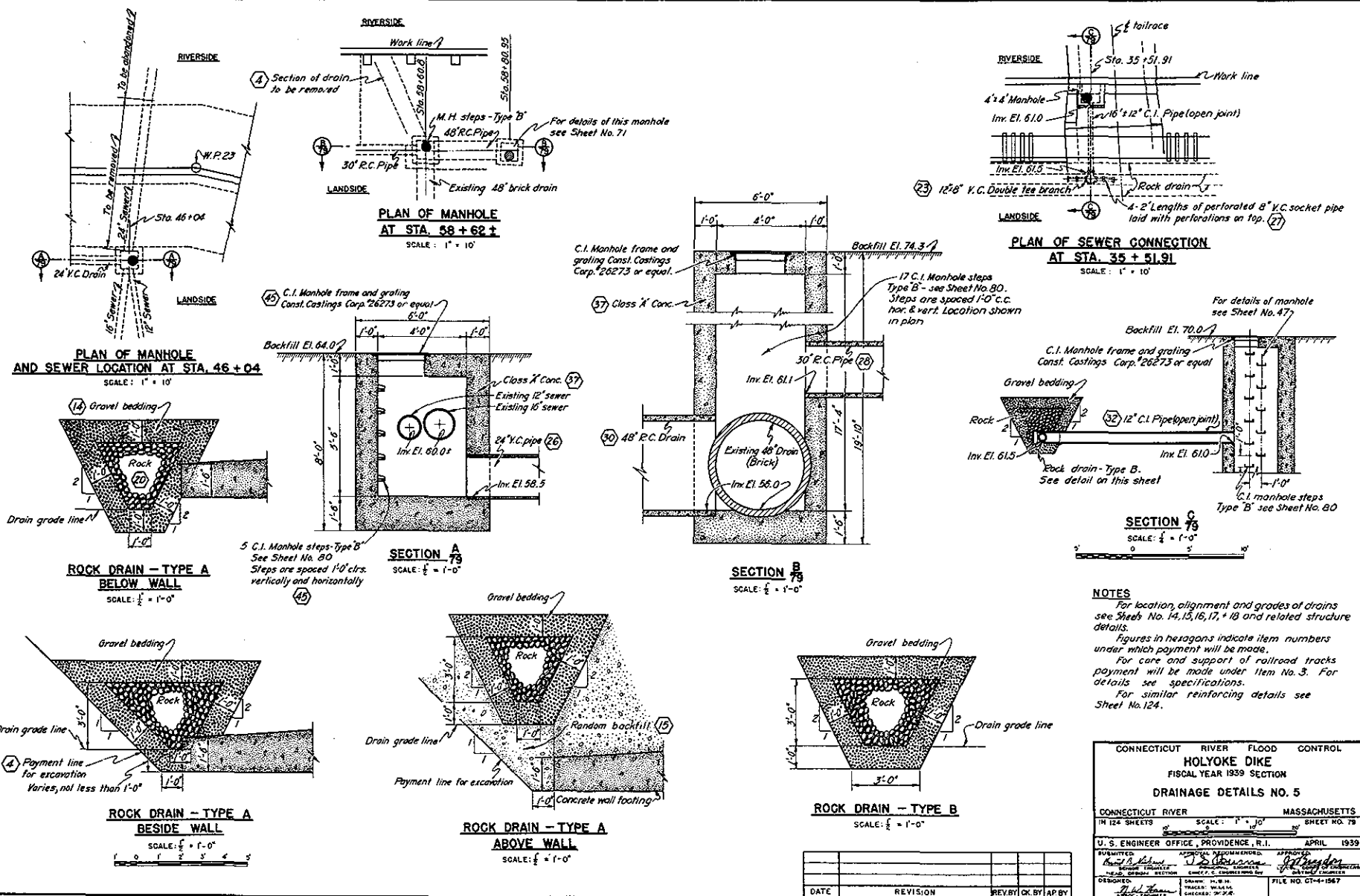


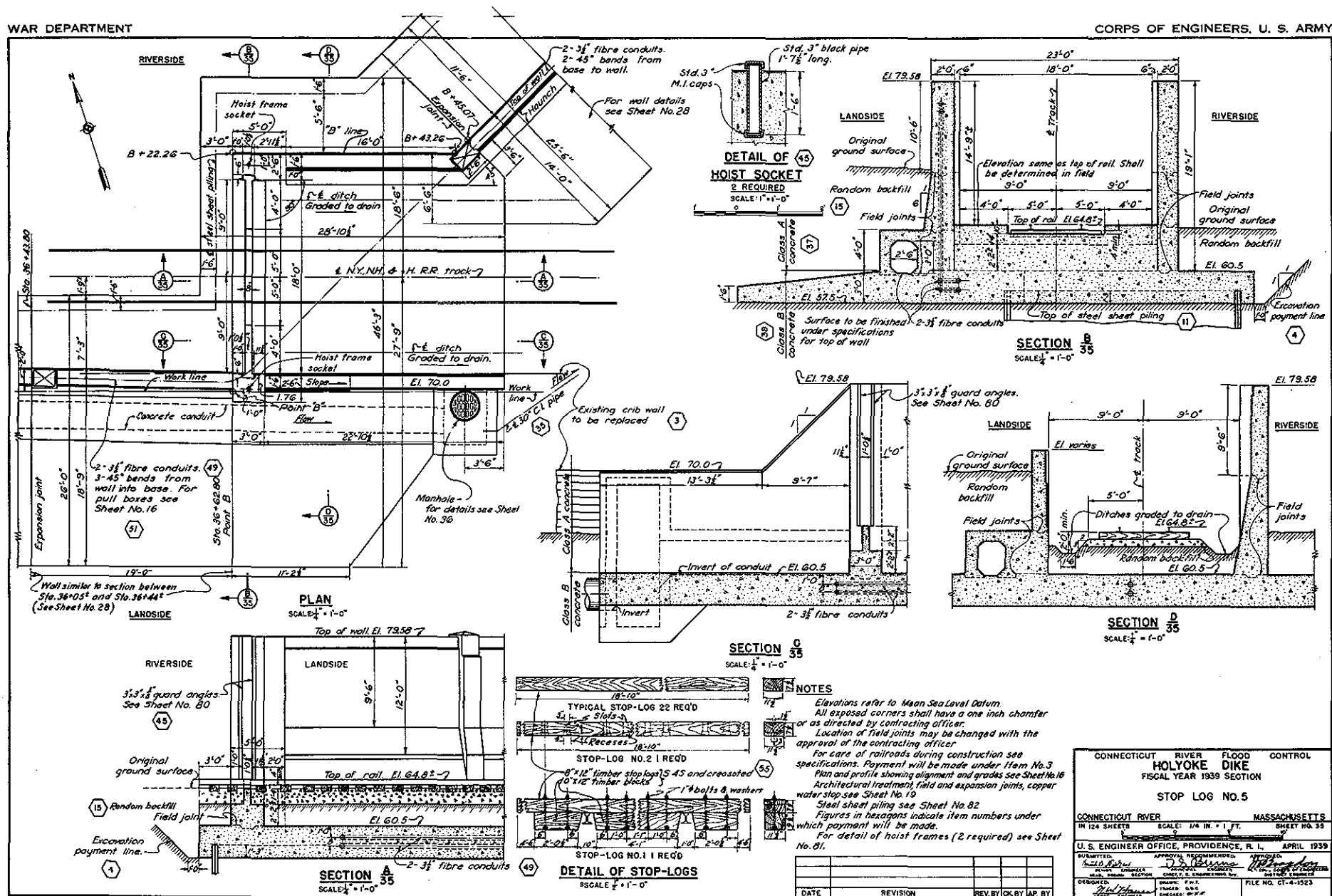


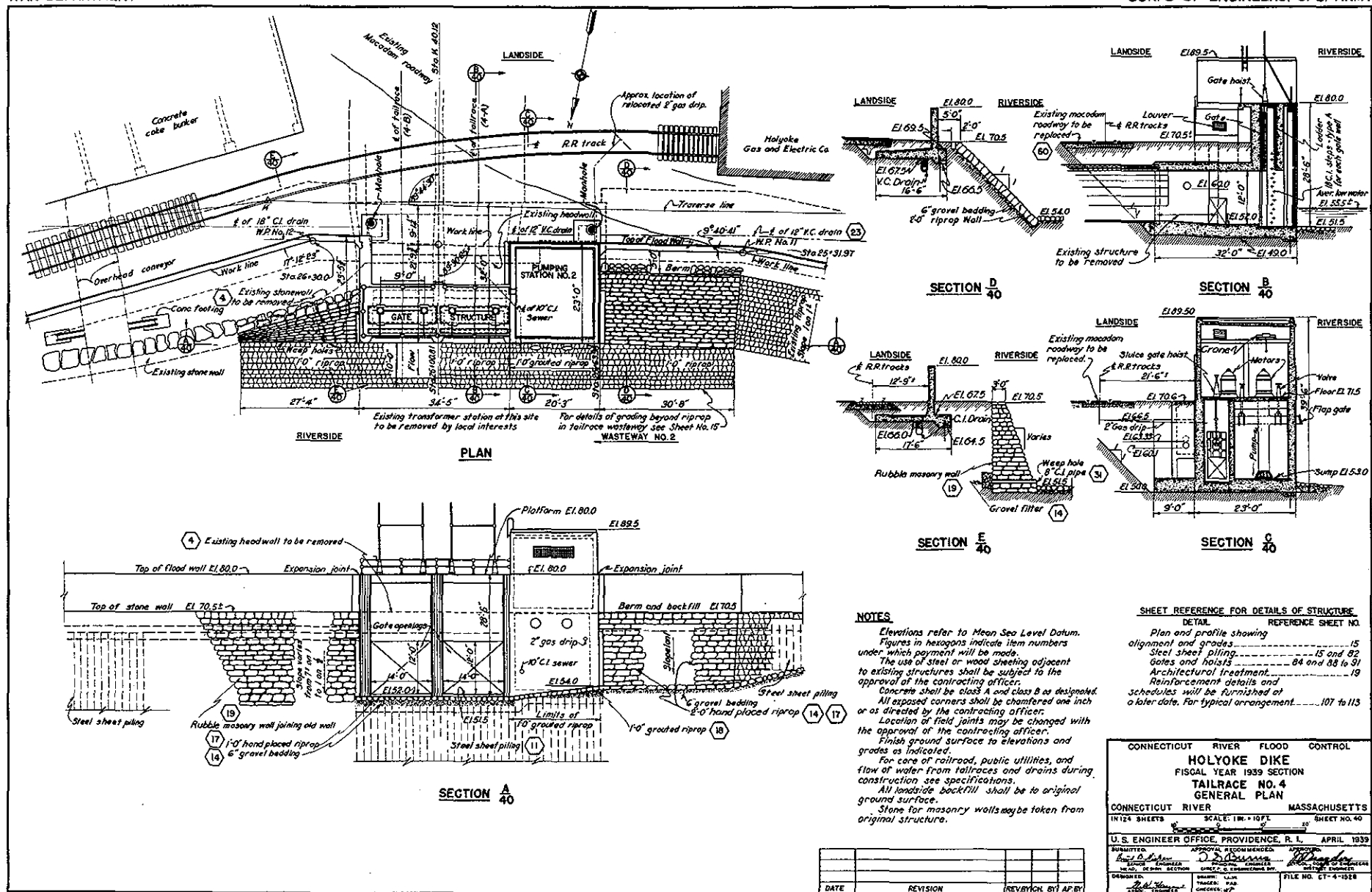
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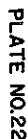


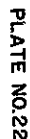


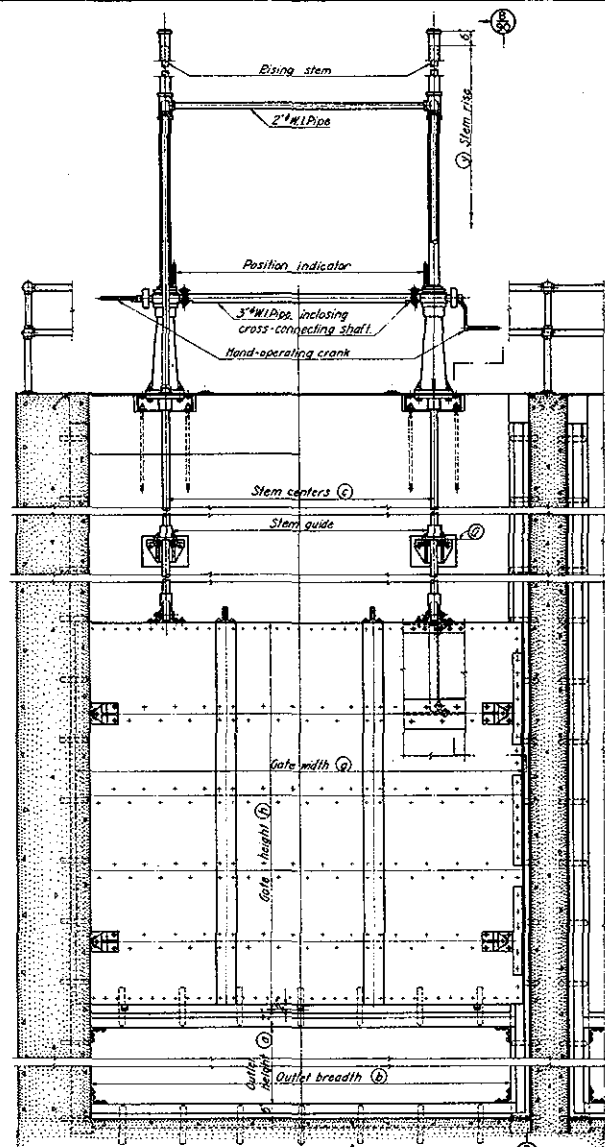




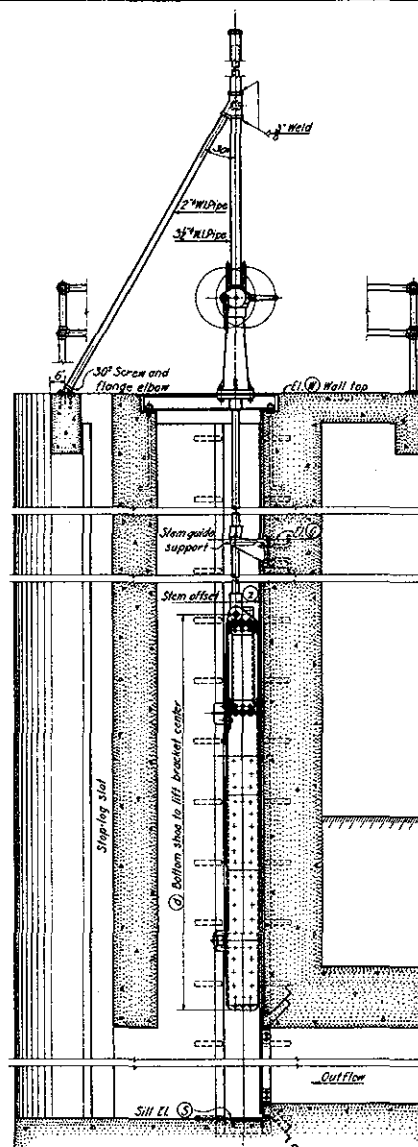




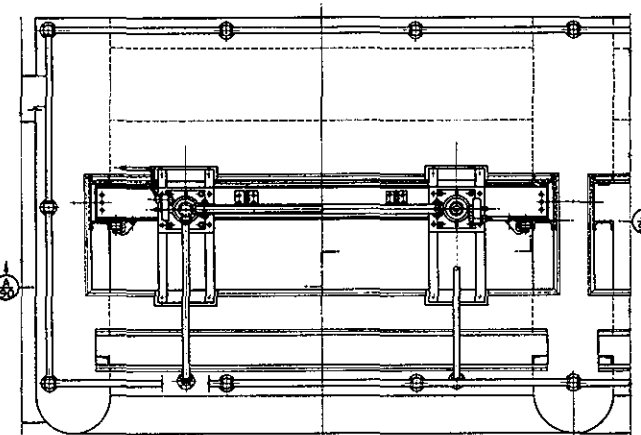




SECTION A 90
(SHOWING GATE IN RAISED POSITION)



SECTION B 90



PLAN
(FLOOR PLATES REMOVED)

GATE DIMENSIONS, OUTLETS 1 TO 12													
OUTLET		GATE				ELEVATION				STEM			
NO.	WIDTH	HEIGHT	REG'D	WIDTH	HEIGHT	GROSS	TOP	SILL	GRADE	CYCLE	RISE	EXTENT	
b	d	e	f	g	h	i	j	k	l	m	n	o	p
1	10'-0"	11'-0"	2	11'-0"	11'-0"	12'-1"	8000	515	-	7'-4"	12'-1"	8'-1"	
4	14'-0"	12'-0"	2	15'-0"	12'-0"	13'-1"	8000	515	-	9'-0"	13'-1"	8'-1"	
6	14'-0"	12'-0"	1	15'-0"	12'-0"	13'-1"	7983	415	660	9'-0"	13'-1"	8'-1"	
7	13'-0"	11'-0"	3	14'-0"	11'-0"	12'-1"	7892	415	670	9'-0"	12'-1"	8'-1"	
8a	13'-0"	11'-0"	1	14'-0"	11'-0"	12'-1"	7842	405	660	9'-0"	12'-1"	8'-1"	
8b	10'-0"	11'-0"	1	11'-0"	11'-0"	12'-1"	7842	405	660	7'-4"	12'-1"	8'-1"	
9	14'-0"	12'-0"	1	15'-0"	12'-0"	13'-1"	7735	405	660	9'-0"	13'-1"	8'-1"	
10	10'-0"	11'-0"	2	11'-0"	11'-0"	12'-1"	7700	405	660	7'-4"	12'-1"	8'-1"	
11	13'-0"	11'-0"	1	14'-0"	11'-0"	12'-1"	7650	405	660	9'-0"	12'-1"	8'-1"	
12	10'-0"	11'-0"	2	11'-0"	11'-0"	12'-1"	7625	385	640	7'-4"	12'-1"	8'-1"	

NOTES

Furnishing and installing flood gates and gate guides will be paid for under Item No. 41

Furnishing and installing gate hoist complete with stem, stem guide, stem housing, bracing and hoist supports will be paid for under Item No. 42

CONNECTICUT RIVER FLOOD CONTROL
HOLYOKE DIKE
FISCAL YEAR 1939 SECTION

GENERAL ARRANGEMENT OF GATE HOISTS

CONNECTICUT RIVER MASSACHUSETTS

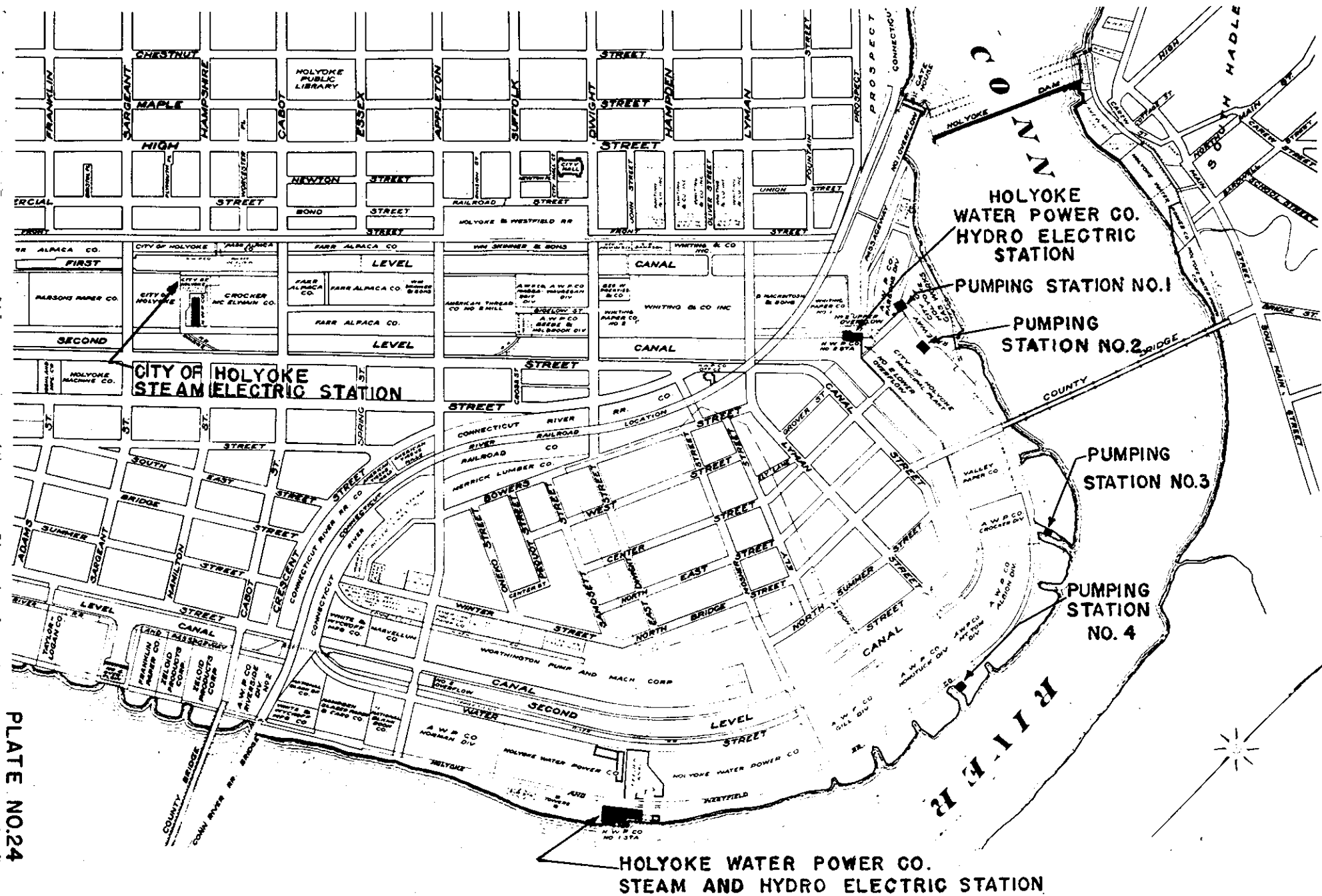
11124 SHEETS SCALE: 1/2" = 1'-0" SHEET NO. 90

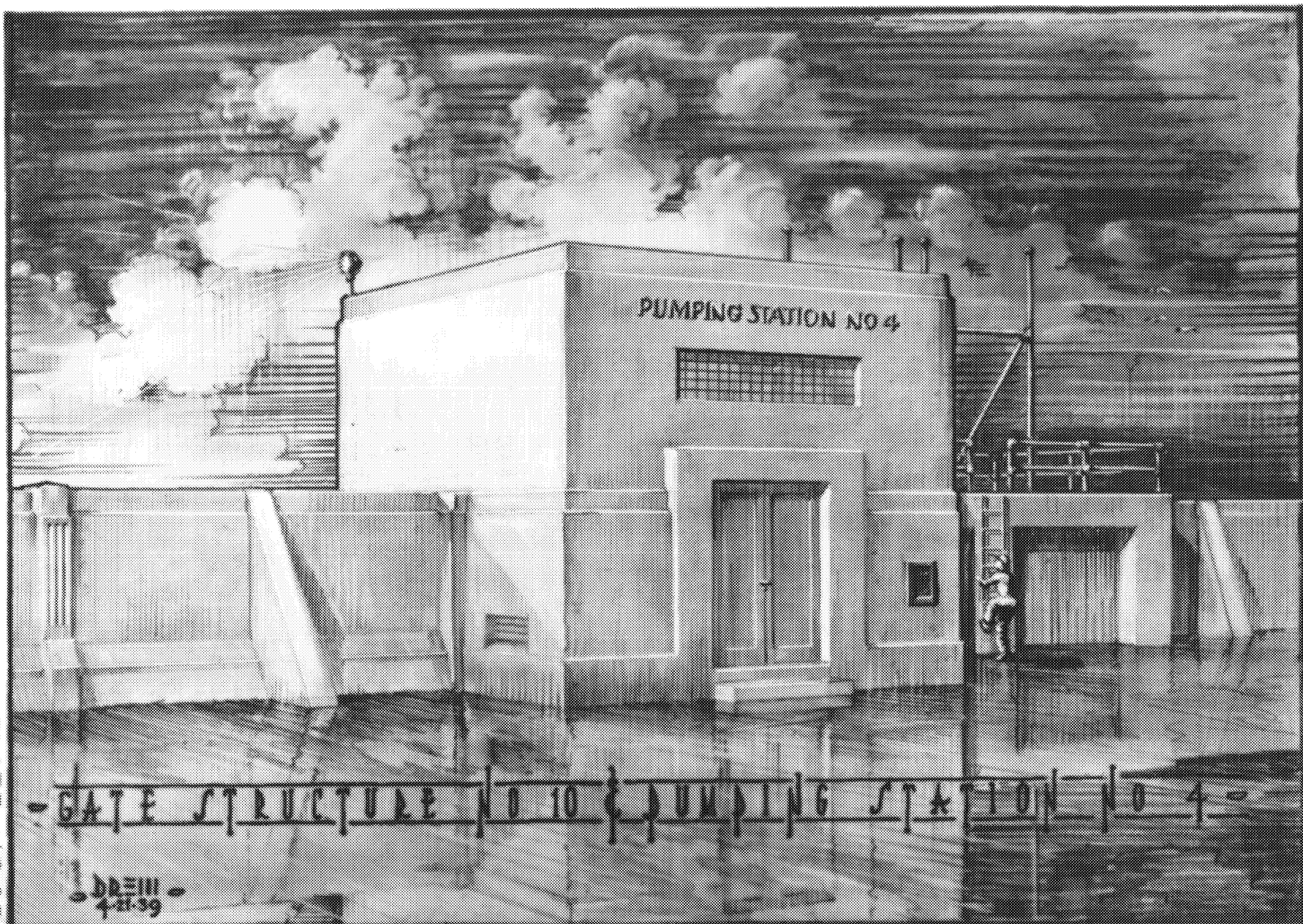
U. S. ENGINEER OFFICE, PROVIDENCE, R. I. APRIL 1939

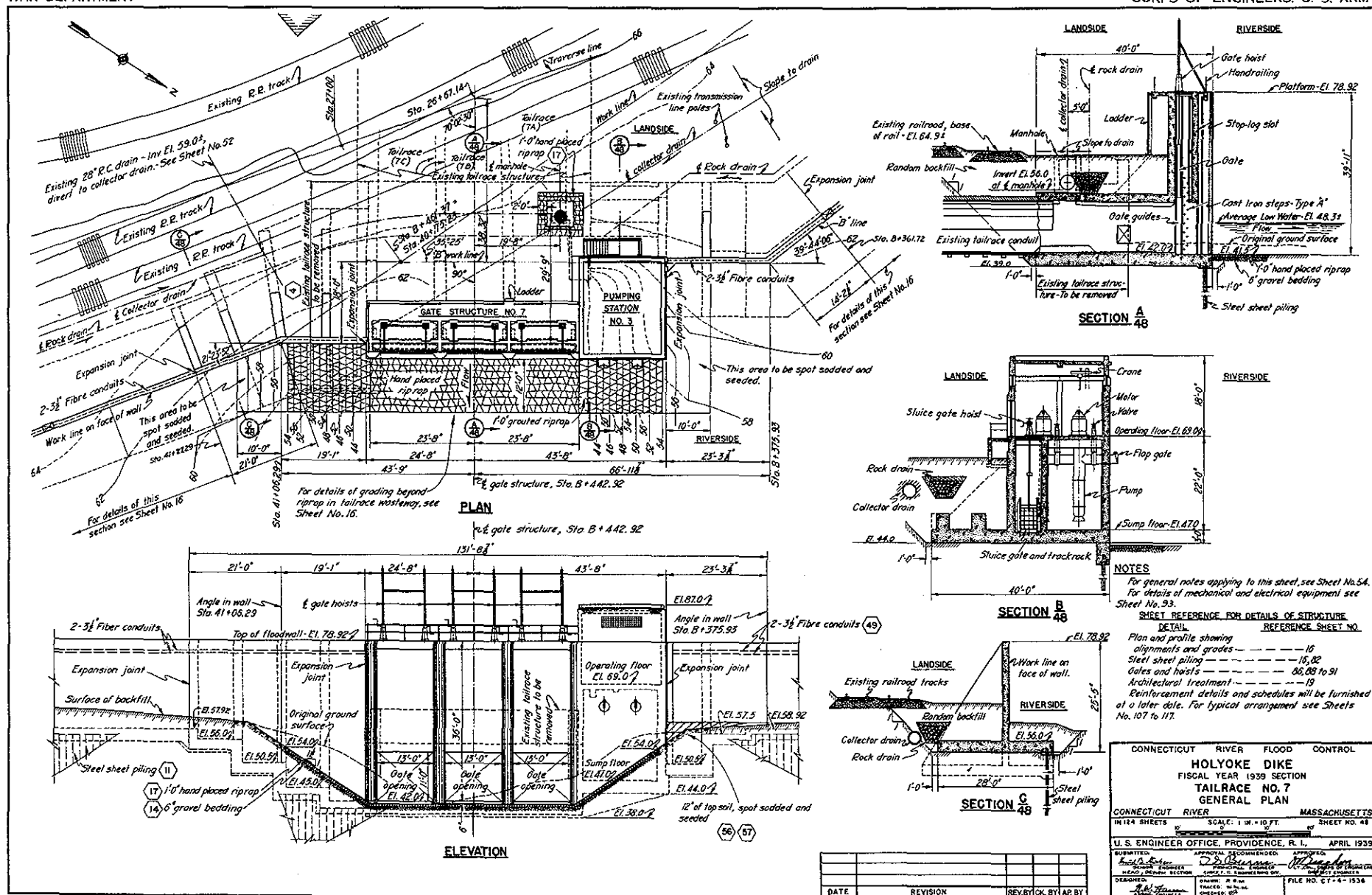
SUBMITTED: APPROVAL: RECOMMENDED: APPROVED:

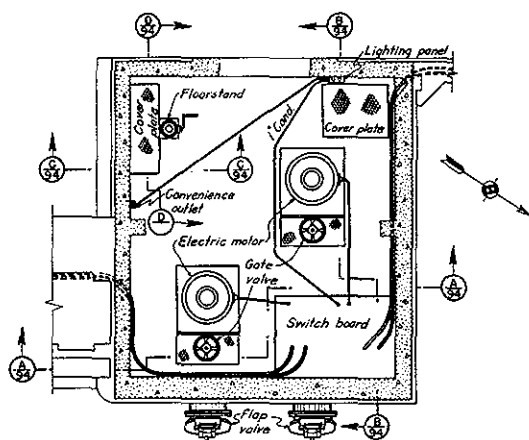
DESIGNED: DRAWN: CHECKED: TRACES: FILE NO. CT-4-1578

DATE	REVISION	REVIEW	CHKD	APBY



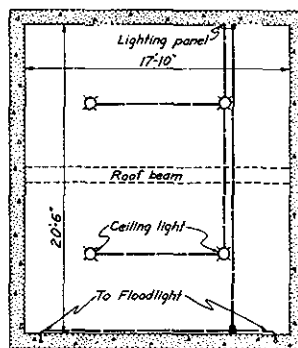






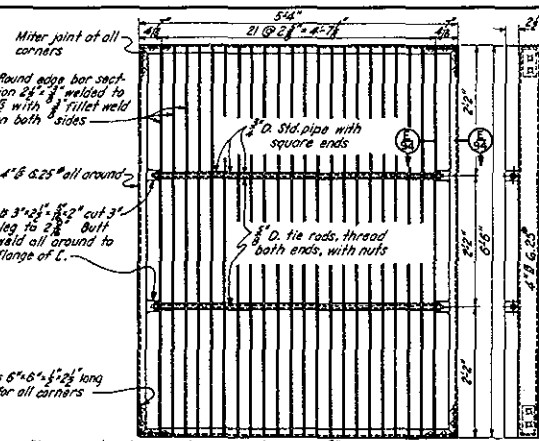
FLOOR PLAN

SCALE 1/4" = 1'-0"



CEILING PLAN

SCALE 1/4" = 1'-0"



Flanges and webs of mitters connected with 3/4" continuous welds; grind to permit fitting of connection b. Grind outside surfaces smooth.

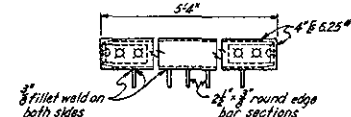
TRASH RACK DETAILS

4 REQ'D WT. 645 LBS. EACH

SCALE 1" = 1'-0"

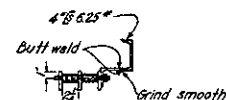
NOTE

Rivets 3/4", open holes 1 1/2" except holes for 3/4" bars which are 1 1/4"



PLAN SHOWING CONNECTION OF BAR SECTIONS

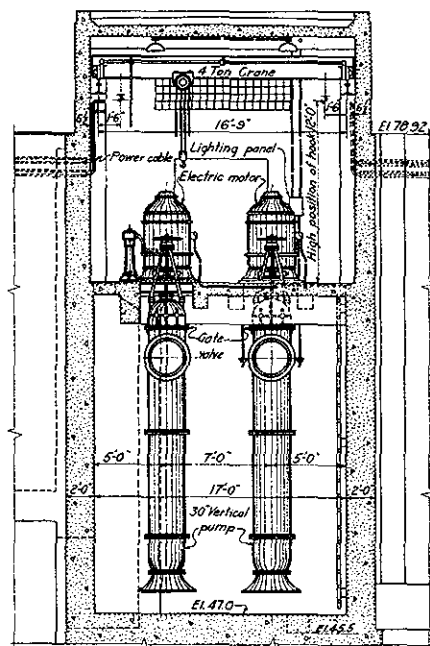
SCALE 1 1/2" = 1'-0"



SECTION E

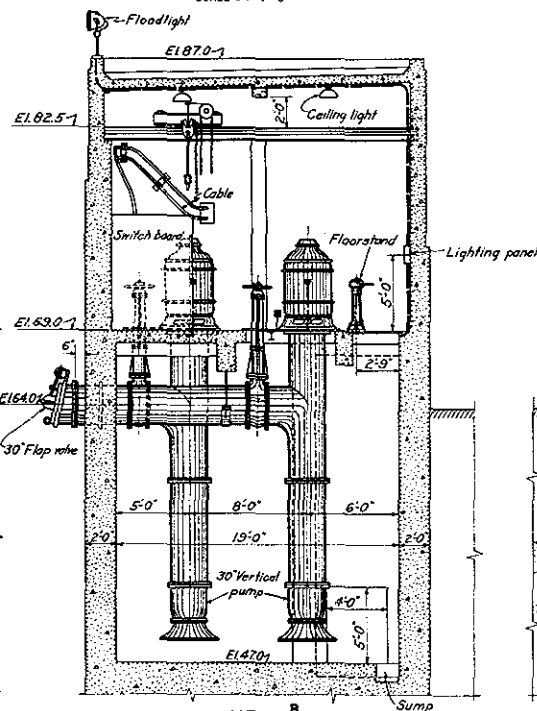
TIE ROD AND L CONNECTION

SCALE 1 1/2" = 1'-0"



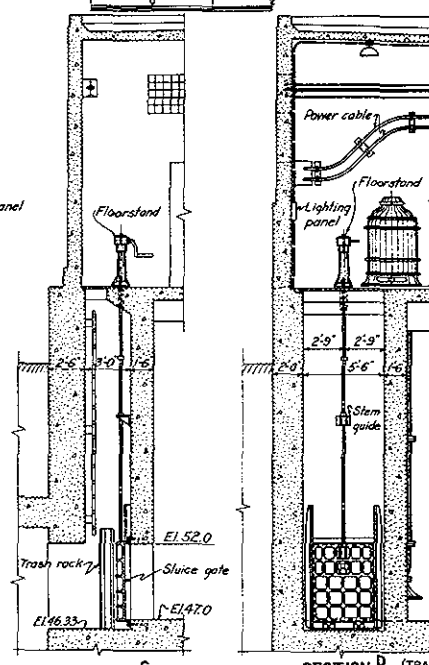
SECTION A-A

SCALE 1/2" = 1'-0"



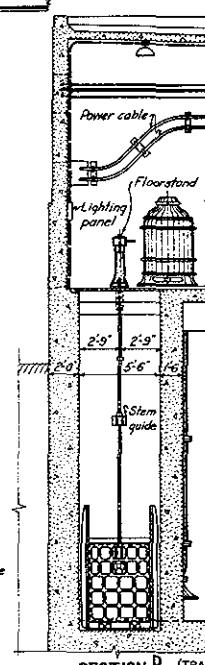
SECTION B-B

SCALE 1/4" = 1'-0"



SECTION C-C

SCALE 1/4" = 1'-0"



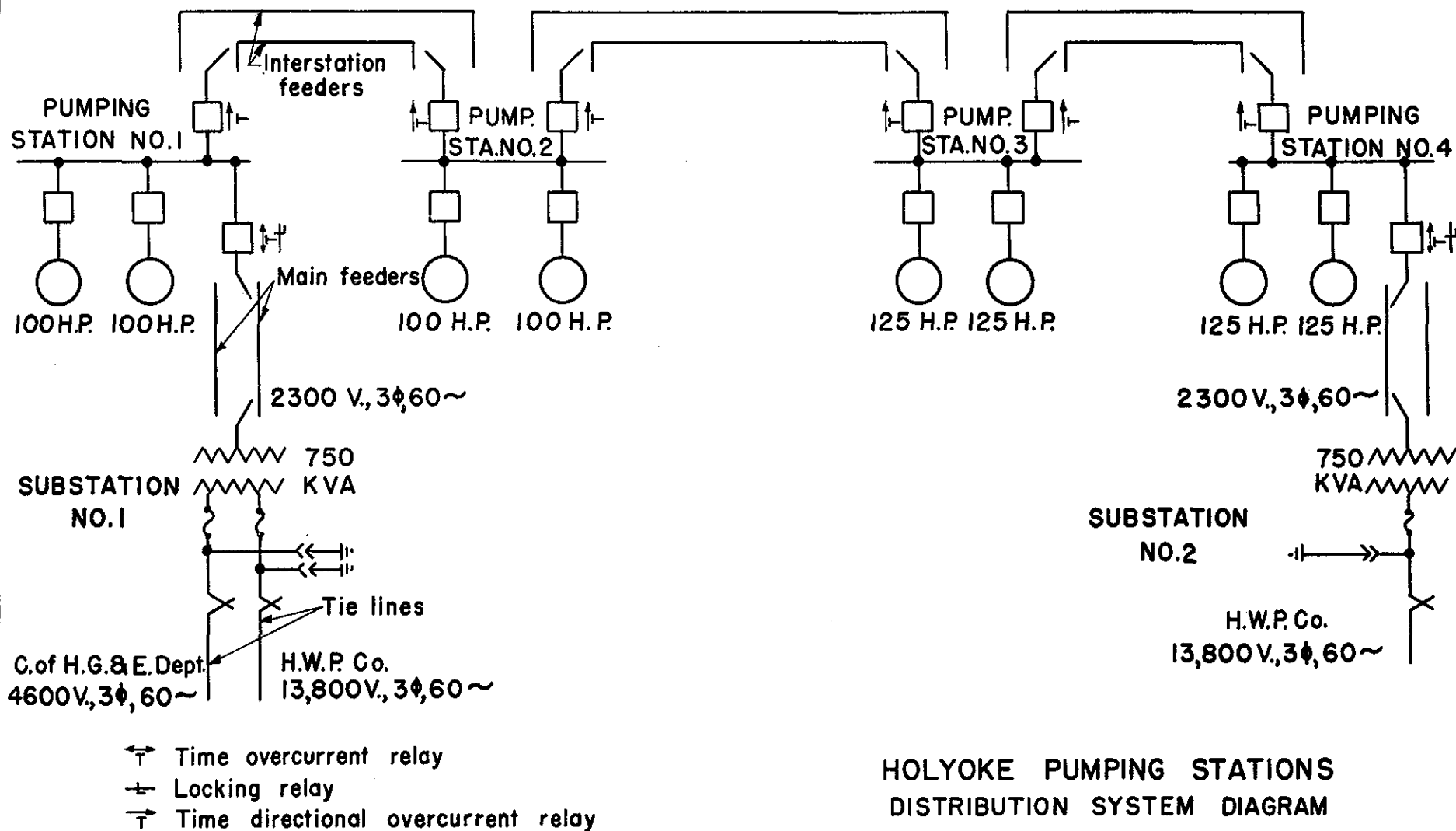
SECTION D-D

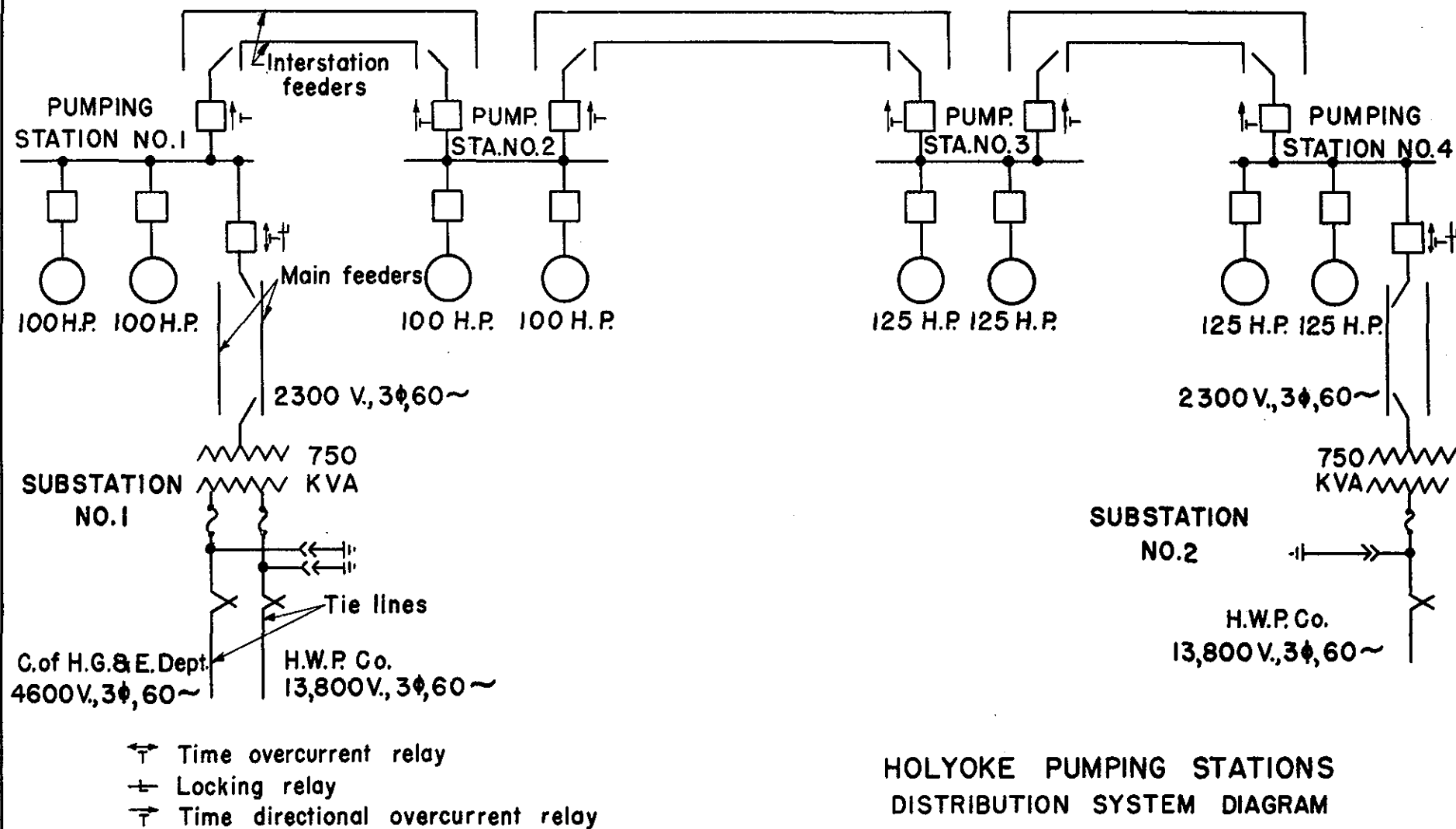
SCALE 1/4" = 1'-0"

NOTES

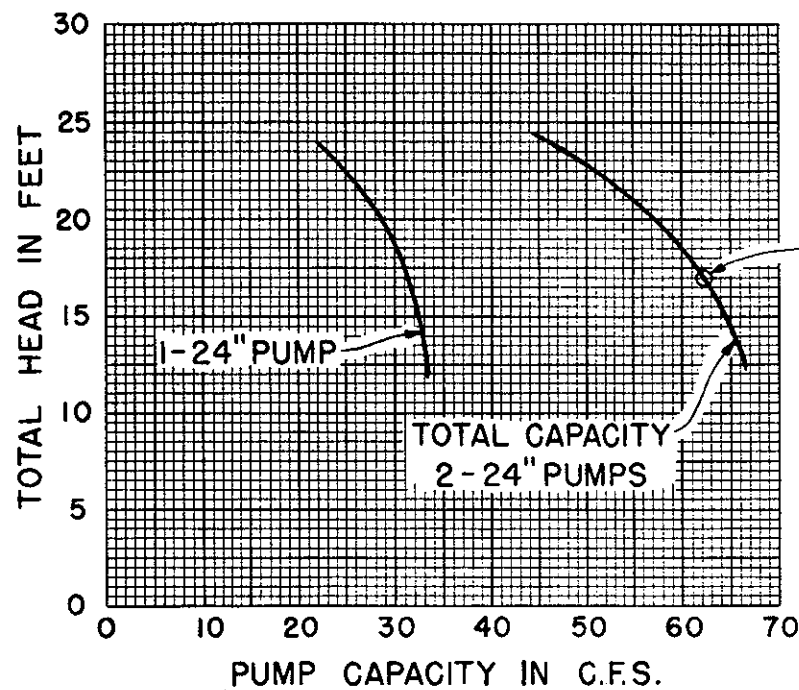
- Installation of pumps, motors, valves, piping and switchboard will be paid for under item No. 52. Furnishing and installing crane will be paid for under item No. 44. Furnishing and installing sluice gate and floor stand will be paid for under item No. 43. Furnishing and installing lighting system will be paid for under item No. 45. Concealed conduits are indicated by solid lines. Exposed conduits are indicated by dashed lines. All motor feeder conduits shall be 2 inch. All lighting conduits shall be 3/4 inch unless otherwise noted. Floor details, pump outlines, piping and other appurtenant features are subject to change depending upon equipment to be installed. The exact location of the pumps and valves shall suit the equipment furnished. Furnishing and installing trash rack will be paid for under item No. 45. For details of trash rack guide angles see Sheet No. 42.

DATE	REVISION	REVIEW	CHK BY	APR BY
CONNECTICUT RIVER FLOOD CONTROL				
HOLYOKE DIKE				
FISCAL YEAR 1939 SECTION				
PUMPING STATION NO. 3				
MECHANICAL AND ELECTRICAL DETAILS				
CONNECTICUT RIVER MASSACHUSETTS				
11 124 SHEETS		SCALE 1/4" = 1'-0"		SHEET NO. 94
U.S. ENGINEER OFFICE, PROVIDENCE, R. I., APRIL 1939				
SUBMITTED		APPROVED		APPROVED
DESIGNED		CHECKED		FILE NO. CT-A-1562





HOLYOKE DIKE PUMPING STATION NO. 1 PUMPING CAPACITY



TOTAL STATION
DESIGN POINT

Top of flood wall
Max. high water El. 80.0

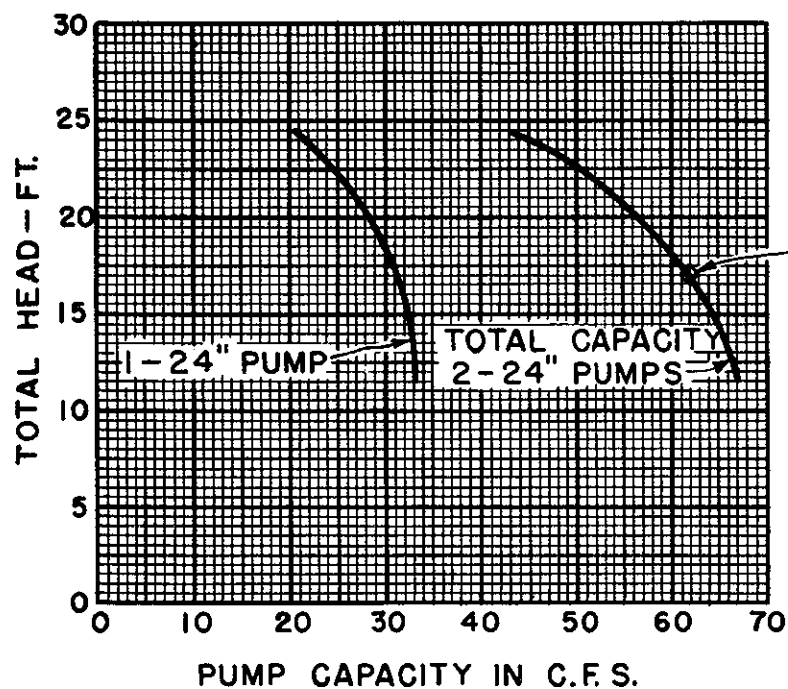
Discharge pipe El. 69.42

Water in sump Min. El. 57.5

Bottom of sump El. 53.0

PUMPING
RANGE

HOLYOKE DIKE PUMPING STATION NO. 2 PUMPING CAPACITY



Top of flood wall
Max. high water El. 80.0

TOTAL STATION
DESIGN POINT

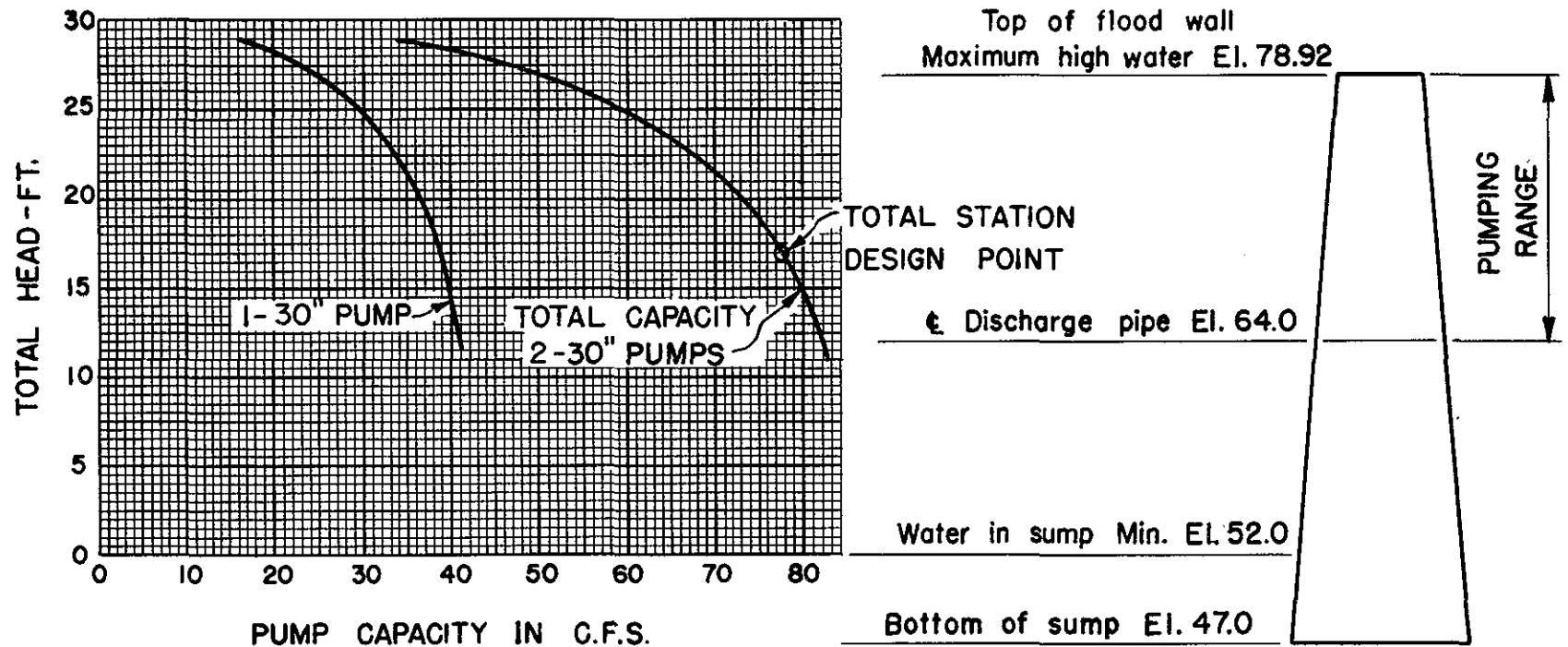
± Discharge pipe El. 67.92

Water in sump Min. El. 57.5

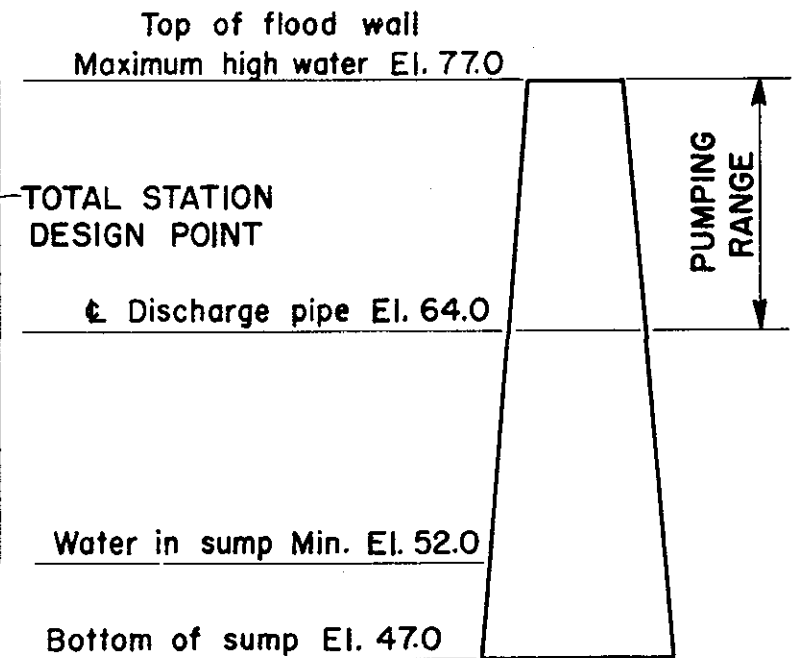
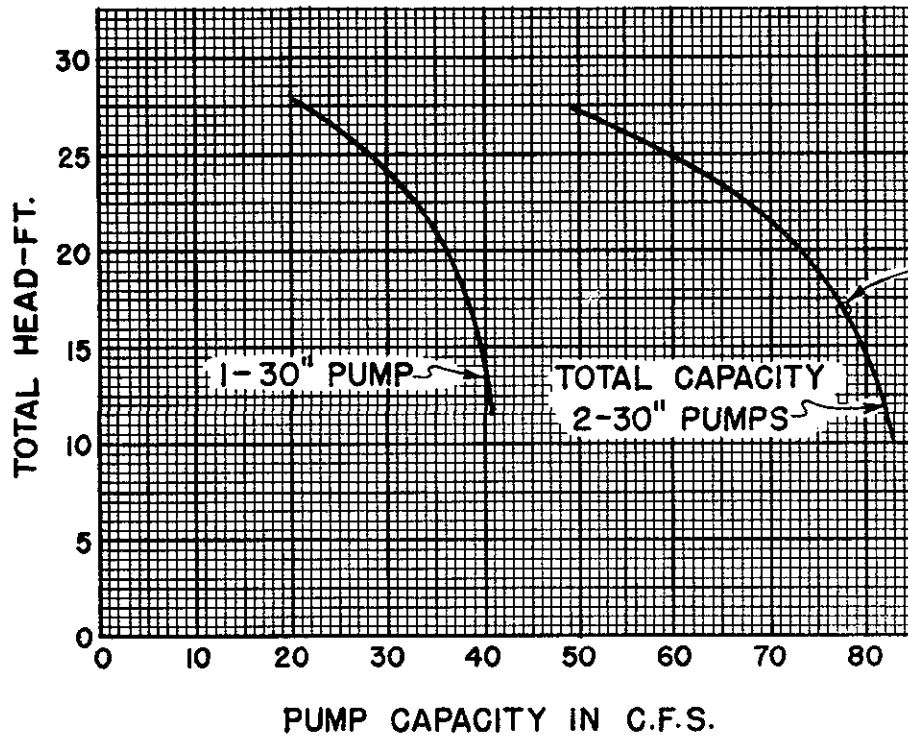
Bottom of sump El. 53.0

PUMPING
RANGE

HOLYOKE DIKE PUMPING STATION NO.3 PUMPING CAPACITY



HOLYOKE DIKE PUMPING STATION NO. 4 PUMPING CAPACITY



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Lt. Col. J.S. Bragdon

ADMINISTRATIVE DIVISION
Major L.A. Murray
Executive Officer

FLOOD CONTROL
ENGINEERING DIVISION
T.S. Burns, Principal Engr.

FLOOD CONTROL
OPERATIONS DIVISION
Capt. R.E. York

RIVERS AND HARBORS DIVISION
Capt. H.J. Hoeffer

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HYDRAULICS AND REPORTS
J.B. Drisko, Engineer

SPECIFICATIONS & ESTIMATES
A.H. Davison, Engineer

GEOLOGY
F.E. Fahlquist, Sr. Geologist

SOILS LABORATORY
W.I. Kenerson, Assoc. Engineer

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L.F. Harza
J.D. Justin
W.F. Uhl

UNION VILLAGE DAM
A.D. Mugnier, Assoc. Engineer

EXAMS. AND SURVEYS
G.H. Mittendorf, Assoc. Engineer

DRAFTING
I.C. Whipple, Assoc. Engineer

DRILLING PARTIES 1 & 5
J.E. Morton, Inspector

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SOILS CONSULTANTS

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T.A. Middlebrooks

SURRY MT. DAM
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H.L. INSPECTION
W.C. Thornton, Jr. Engineer

DRILLING PARTIES 2, 3 & 4
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KNIGHTVILLE DAM
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Miss C.R. Cox, Clerk

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H.J. Kropper, Assoc. Engineer

FIELD SURVEYS
H.C. Dreher, Asst. Engineer

HYDRAULIC LABORATORY
ALDEN HYD. LAB., WORCESTER
Prof. C.E. Allen, Director

STRUCTURAL DESIGN
J.C. Dingwall, Assoc. Engineer

DIKES
I.O. Thorley, Assoc. Engineer

A.D. Mugnier, Assoc. Engineer
J. Hartler, Assoc. Engineer
N.W. Haner, Assoc. Engineer
P. Hanscomb, Asst. Engineer

ORGANIZATION CHART
FLOOD CONTROL
ENGINEERING DIVISION
U.S. ENGINEER OFFICE, PROVIDENCE, R. I.